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STATE EXPERIMENT STATION

BULLETIN

OF THE

LOUISIANA

GEOLOGICAL SURVEY

No. 1.

UNDERGROUND WATERS OF LOUISIANA

BATON ROUGE

1905

BULL. No. 1 REPORT OF 1905

GEOLOGICAL SURVEY OF LOUISIANA

GILBERT D. HARRIS, *Geologist-in-Charge*

A REPORT

ON

THE UNDERGROUND WATERS

OF

LOUISIANA

BY

G. D. HARRIS, A. C. VEATCH, AND OTHERS

MADE UNDER THE DIRECTION OF THE STATE EXPERIMENT STATIONS,

WM. C. STUBBS, *Director*

BATON ROUGE, LA.
1905

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Part I

Part II

STATE EXPERIMENT STATION,
BATON ROUGE, LA., Dec. 29, 1904.

TO HIS EXCELLENCY, NEWTON C. BLANCHARD, GOVERNOR OF LOUISIANA:

Sir:—I have the pleasure to transmit herewith Bulletin No. 1 of the Louisiana State Geological Survey. It includes all present available knowledge regarding the underground waters of Louisiana. Many are the letters we receive asking for information regarding artesian and deep well prospects in every portion of the State. This bulletin is a general reply to all these inquiries. It will be seen that by consulting the maps of different sections of the State, a very fair estimate can be made of the underground water-prospects of any district. The well sections, as published in the text of the report, show about what may be expected as regards the nature and thickness of the various strata penetrated before water is reached.

The bulletins which follow will deal with salt, lignite, oil, etc., but these products are of most trifling account when compared to the great underground water supplies of the State. The facts herein recorded are based on careful observations covering a period of three or four years. The matter of the stratigraphic relations of the various water-bearing horizons has been worked out mainly by comparing well records in connection with the exact heights of the wells above sea level. Much attention has been given to spirit leveling for this work alone. Mr. Veatch who worked conjointly for the United States and Louisiana surveys, has, as you will observe, written Part II relating to the northern part of the State, and has compiled for future reference a lengthy catalogue of localities with true heights above mean gulf level. The same will be of value also for our future topographic work in this part of the State.

Respectfully submitted,

WM. C. STUBBS, *Director*

LETTER OF TRANSMITTAL

BY

G. D. HARRIS, GEOLOGIST-IN-CHARGE

LAFAYETTE, LA., Dec. 26, 1904.

DR. WM. C. STUBBS,

Director of Experiment Stations, La.

Sir:—In accordance with your wishes I have prepared the various papers constituting the third geological report under my charge for publication as separate *Bulletins*, but at least one-half the edition will be held back and bound in one volume, styled the Report of 1905, similar in many respects to our reports of 1899 and 1902.

The purport of the present work, *Bulletin No. 1*, is obvious; the demand for it has, as you know, been great. A glance at the table of contents will show what has already been accomplished.

This is but one of many special works you have had the foresight to see the coming need for, and to have prepared for the progress of the commonwealth whose interests you hold so truly at heart.

It is most pleasant to recall the fact that during the past six winters' work, you have cheerfully, promptly, knowingly expedited all matters relating to our State survey with no compensation whatever save the knowledge of seeing the right thing done at the right time. No one can appreciate more truly the value of such sincere assistance than

Yours most faithfully,

G. D. HARRIS

Compiled from maps of the U.S. Land Office, U.S. Engineers Report
U.S. Coast and Geodetic Survey, Railroad profiles
State Geological Survey of Louisiana, and U.S. Geological Survey

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PART I

UNDERGROUND WATERS OF SOUTHERN LOUISIANA

BY G. D. HARRIS

INTRODUCTION

The serious study of the underground waters of Louisiana was begun during the winter of 1899–1900 by members of the State Geological Survey. The first report of progress appeared as "Special Report No. VI" in the Survey's publication of 1902. Subsequent to that date the writer spent the month of June 20 to July 20, 1903, in the same field in behalf of the U. S. Geological Survey. A general report on the underground water of the southern part of the state was prepared that summer for that Survey and in the fall of 1904 it was published as WATER SUPPLY AND IRRIGATION PAPER NO. 101. Part I of the present Bulletin is practically a reprint of this "Water Supply" paper. Part II, written by Mr. A. C. Veatch, represents an outline of the work he carried on in 1902 and 1903 in Louisiana and adjoining states partially in the employ of the Louisiana State Survey and partially as assistant geologist to the National Survey. His full report on these states will doubtless appear early in 1905 from the Government press.

ORIGIN OF ARTESIAN AND DEEP-WELL WATERS IN SOUTHERN LOUISIANA

Precipitation

Last year's Weather Bureau report gives the following figures regarding precipitation at several stations in southern Louisiana :[a]

Precipitation at Stations in Southern Louisiana

Station	1902	Average
Alexandria	45 24	55 95
Amite	41.44	60.41
Cheneyville	40.74	53.18
Clinton	52.29	55.01
Hammond	47.01	58.13
Lafayette	36 35	53 48
Lake Charles	41.19	54 94
Opelousas	39.77	54.64
Sugartown	48 12	54 52

From this it appears that the average annual precipitation in this part of the State is about 55 inches. This means that each acre of land receives more than double enough rain water to irrigate it properly if planted in rice. But much of this water is lost, so far as agricultural purposes are concerned, by flowing away in surface streams to the Gulf. Much, too, that descends into the soil and lower strata of the earth, doubtless leaches out into the Gulf underground. Unfortunately for our present study, the main local streams of southern Louisiana have never been gaged, and consequently the amount of water that reaches the sea, even by surface streams, is not known. The extent, therefore, to which the total amount of rainfall may be utilized as deep-well water can not at present be even approximately estimated. That much rain water is absorbed and transported to distant places through underground porous layers is evident from the existence of many satisfactory deep and artesian wells

[a] U. S. Dept. Agr., Ann. Summary, 1902, Louisiana Section, Weather Bureau Office, New Orleans, La.

throughout the southermost parishes of the State. Yet it is often held that the supply of deep waters may be derived from large bodies of neighboring water—for example, from lakes and rivers and small streams that have a greater altitude than the surface of the water in the deep wells. This may, indeed, be the case in a region in which there are limestone formations, or in a region where the gradient of the streams is considerable and erosion is scouring and cleaning the sides and bottom of the channels and where practically no silt is being deposited, but in Louisiana none of these conditions exist, so far as the larger streams and other large bodies of water are concerned. However, we will consider with all necessary detail two of the common theories advanced to account for the presence of water in such apparently immense quantities beneath the surface in southern Louisiana.

GULF WATER AS A SOURCE OF SUPPLY OF DEEP WELLS

It is frequently asserted that the continuance of southerly winds or high tides causes an appreciable rise in the level of the water in wells not far from the coast; that when wells are vigorously pumped the water level descends below tide; that therefore there is an intimate connection between the waters of the Gulf and those encountered so abundantly in deep wells.

That there is more or less connection between the fresh water under the ground and the salt water of the Gulf there can be no doubt. A variation in the height of the water in a few wells coincident with that in a neighboring body of water in which there is a perceptible tide was long ago recorded by members of the Louisiana State geological survey and others. That there is no underground current from the Gulf landward is evident from the facts (1) that when pumping ceases for a few hours the water level in the wells quickly rises above tide, and (2) that any water derived from the Gulf would possess a saltiness that has not thus far been recorded in any deep irrigation well. Any impediment tending to retard the escape of the underground waters Gulfward, as the weight of water collected from long-continued heavy showers or the backing up of the Gulf's waters from the south,

will necessarily raise the level of the water in the deep wells or cause the artesian wells to flow more strongly.

RIVER WATERS AS A SOURCE OF SUPPLY

In 1860 Raymond Thomassy [a] published his Géologie pratique de la Louisiane. He seems to have been greatly captivated with the idea that a large amount of the water flowing into the Mississippi from its various tributaries never reaches the Gulf by surface streams, but is absorbed by the pervious layers that form the banks and bottom of the river, and is carried thence through underground passages and porous layers to the Gulf coast, or beneath its waters.

Thomassy was of course not aware of the great possibilities of irrigation in southern Louisiana, but had he lived to see hundreds of 10 or 12 inch wells yielding almost rivers of deep, cool water, he would doubtless have felt that his absorption theory was at last fully proved, else whence could all this underground water come?

No definite statements can be made regarding the amount of water furnished by the rivers of Louisiana to the general underground supply until the topography and stratigraphy have been determined in detail. Yet it may be shown here that the oft-repeated popular statement that waters of the Mississippi River supply the wells in southern Louisiana is but partly, if at all, correct. Certainly no "veritable river" is leaving the Mississippi in its lower reaches to force its way laterally for long distance underground. The process of transferring discharge measurements from one point on the river to another, as employed by Humphreys and Abbot [b] in their delta survey, has shown that the difference in discharge at two stations at equal stages in the river is due to increment of water from tributaries and loss in distributary bayous and crevasses between the two places. Daily

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[a] Géologie pratique de la Louisiane, par R. Thomassy (accompagné de 6 planches), chez l'Auteur, à la Nouvelle-Orléans et à Paris, 1860.

[b] Report upon the physics and hydraulics of the Mississippi River; upon the protection of the alluvial region, from overflow, etc.: Professional Paper No. 13, Corps of Engineers, U. S. Army, 1861. See reprint of 1876, pp. 280, 358–363.

discharge measurements made at Vicksburg were compared with discharge measurements made at stations up and down the river, and these agreed in a remarkable way.

In other words, there is no difference in the amounts of discharge at Vicksburg and Carrollton, for example, that can not be explained by taking into account the difference between water received and that given up by surface channels. The absorption, therefore, of the Mississippi's waters by underground porous layers, is a subject that is of no importance in the present report.

The impropriety of assuming that variations in "head" noticed in deep wells located at any considerable distance from the Mississippi are due to difference in the stage or height of the river, is evident from facts presented farther on in this report. It is fortunate that the measurements of well stages here recorded were made mostly in the spring of 1901, especially in April and May. The wells showed a slight temporary rise about April 22, due to local showers, but thereafter the usual marked decline for the summer went steadily on. Not so the river; it gradually rose till it reached the highest point of the season on the dates which follow, at the localities designated:[a] May 16, Vicksburg, Miss.; May 15–16, St. Joseph, La.; May 16–17, Natchez; May 17, Red River Landing; May 17, Bayou Sara; May 17, Baton Rouge; May 16, Plaquemine; May 19, Donaldsonville; May 15, College Point; May 17 and 20, Carrolton. After these dates, at the stations named, the river began to decline.

The cross sections presented in figs. 8 and 9 (pp. 29, 30) show clearly the behavior of deep waters in the vicinity of large stream channels. There is therefore reason to suppose that the Mississippi and other large streams serve as drains on the underground-water supply rather than as feeders.

TOPOGRAPHY OF SOUTHERN LOUISIANA

Since the cause of flow of underground waters must be due mainly to the action of gravity, it follows that the surface features of the land have a marked influence on the rate of under-

[a] Stages of the Mississippi, etc.: Miss. Riv. Comm., 1901, St. Louis, Mo., Mississippi River Commission Print, 1902.

ground as well as of over-ground flow. Southern Louisiana has only just begun to coöperate with the General Government in the construction of detailed topographic maps, so it is not possible to show the surface features as well as could be desired ; yet private individuals, corporations(such as railroad and canal companies), United States engineers, and members of the State geological survey have done a large amount of spirit leveling throughout the area, and from such data it has been found possible to compile a small-scale contour map (Pl. I) and a still smaller index map (fig. 1) to the topography of this part of the State.

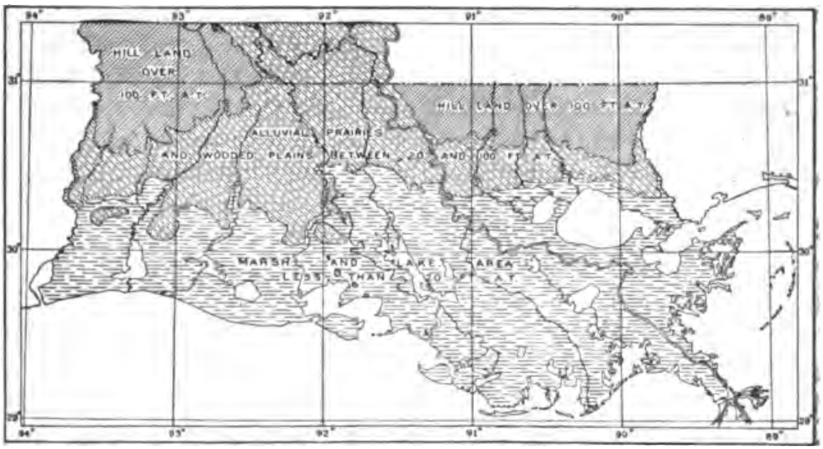


FIG. 1.—Map showing topographic subdivisions of southern Louisiana

TOPOGRAPHIC SUBDIVISIONS

MARSH-LAKE AREA

To this subdivision may be assigned in general that portion of the State having an elevation above tide of less than 20 feet (see fig. 1). Its size is surprisingly great when compared with that of the more elevated areas. Pl. I represents an area in Louisiana, exclusive of large lakes, bays, etc., covering 28,900 square miles, of which 15,800 are below the 20-foot contour. The Five Islands in Iberia and St. Mary parishes are the only areas furnishing what might be called notable relief in this subdivision

of southern Louisiana. One "island" rises to a height of 150 feet above the surrounding marsh land; others are but two-thirds or half as high. Since, however, the diameter of the largest is only approximately 2 miles, their total area is extremely insignificant when compared with the vast extent of low land shown on the map. Southern Cameron and Vermilion parishes contain extensive swamp tracts that lie several miles back from the Gulf border, but close to the Gulf there are several remarkably persisent dry, sandy ridges that rise from 5 to 10 feet above mean tide (see Pl. I). In the swampy areas there are several broad and very shallow lakes or bays, as may be seen by consulting the same plate. They rarely show a depth of more than 15 or 20 feet, usually much less. The bayous and rivers, however, have cut very deep channels through these lowlands. Depths of 30 to 40 feet are by no means unusual, while the Mississippi has long stretches of channel that range in depth from 72 to 90 feet, and occasional pools 200 feet deep. The manner in which the ground slopes above and below Gulf level, the basin-like character of the lakes, and the deepness of the river channels are typically shown in fig. 2.

The topography of the region lying between Lake Pontchartrain and the Atchafalaya River—the so-called delta region of the Mississippi—deserves a few additional remarks.

Large areas in this tract are scarcely above sea level. The figures shown on Pl. I, along the Southern Pacific Railroad from New Orleans to Morgan City, indicate feet above tide. Here, as in all mature river flood plains, there is a tendency to deposit sediment along the immediate banks of the streams so as to form low, natural levees. This feature is indicated to some extent by the figures just referred to, but in the lower delta region it is clearly seen along the sea-level line. Nearly all the streams are leveed, as it were, out into the Gulf, especially the Mississippi.

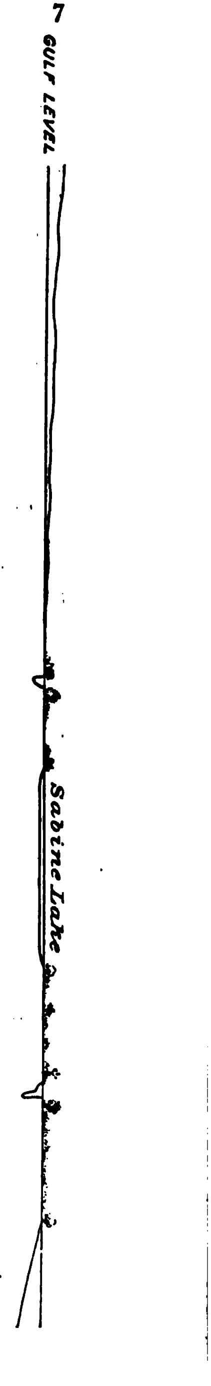


FIG. 2.—North-south section from the Kansas City South Railroad, in Texas, through Sabine Lake and southwestern Cameron Parish, La. Length, 35 miles; extreme elevations, —30 to +30 feet.

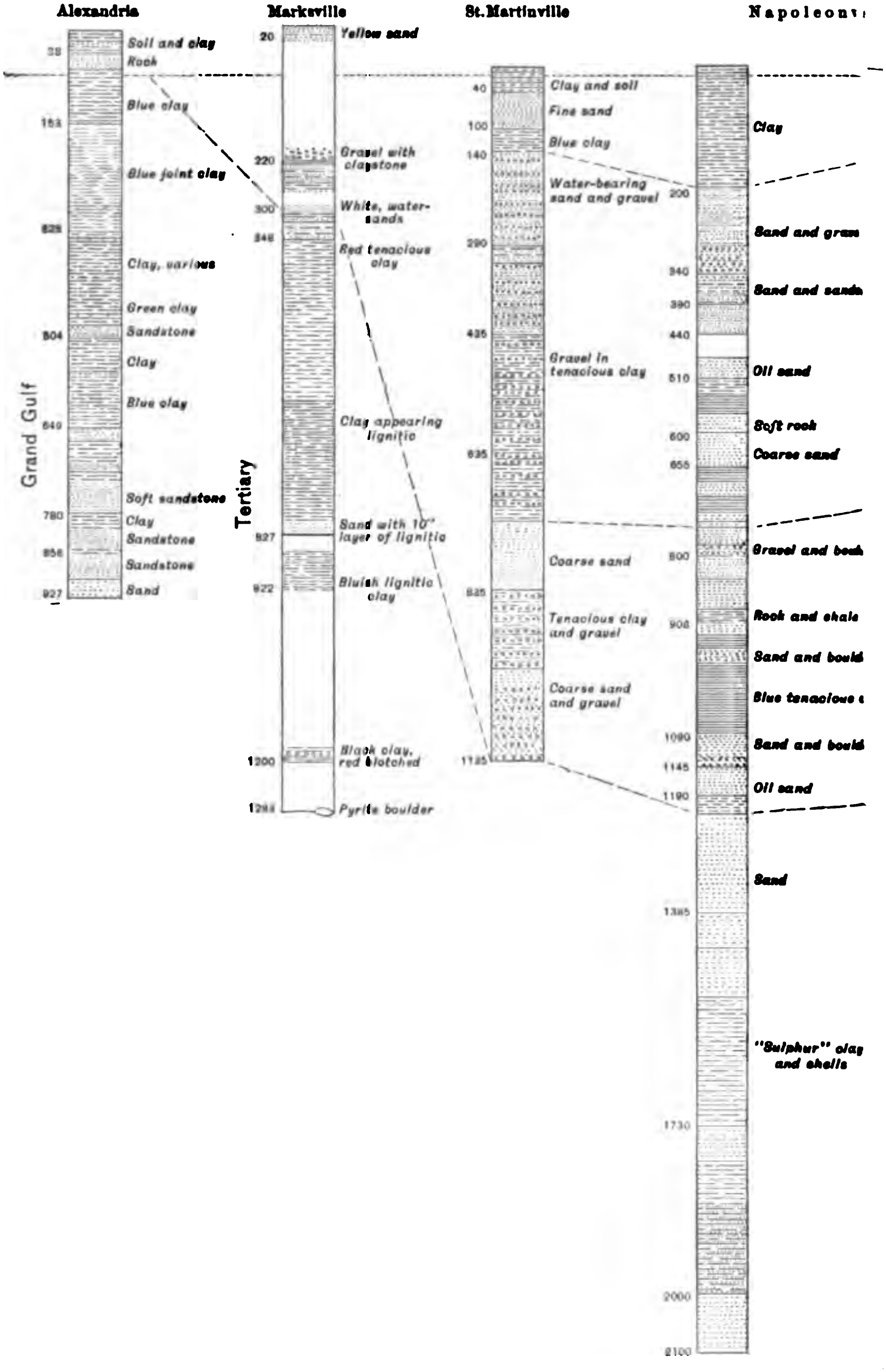
The large quantities of water that have passed over this delta region in comparatively recent geologic times have kept its surface from rising above sea level at the same rate as did adjoining portions of the State lying north, east, and west. The result is that this region has been eroded by waters coming from nearly all the middle Western States, whereas the adjoining tracts have been worn down only by the results of the precipitation upon their own area. Now, river action is gradually building up this delta region, whereas to the east and west the land surface is being gradually degraded.

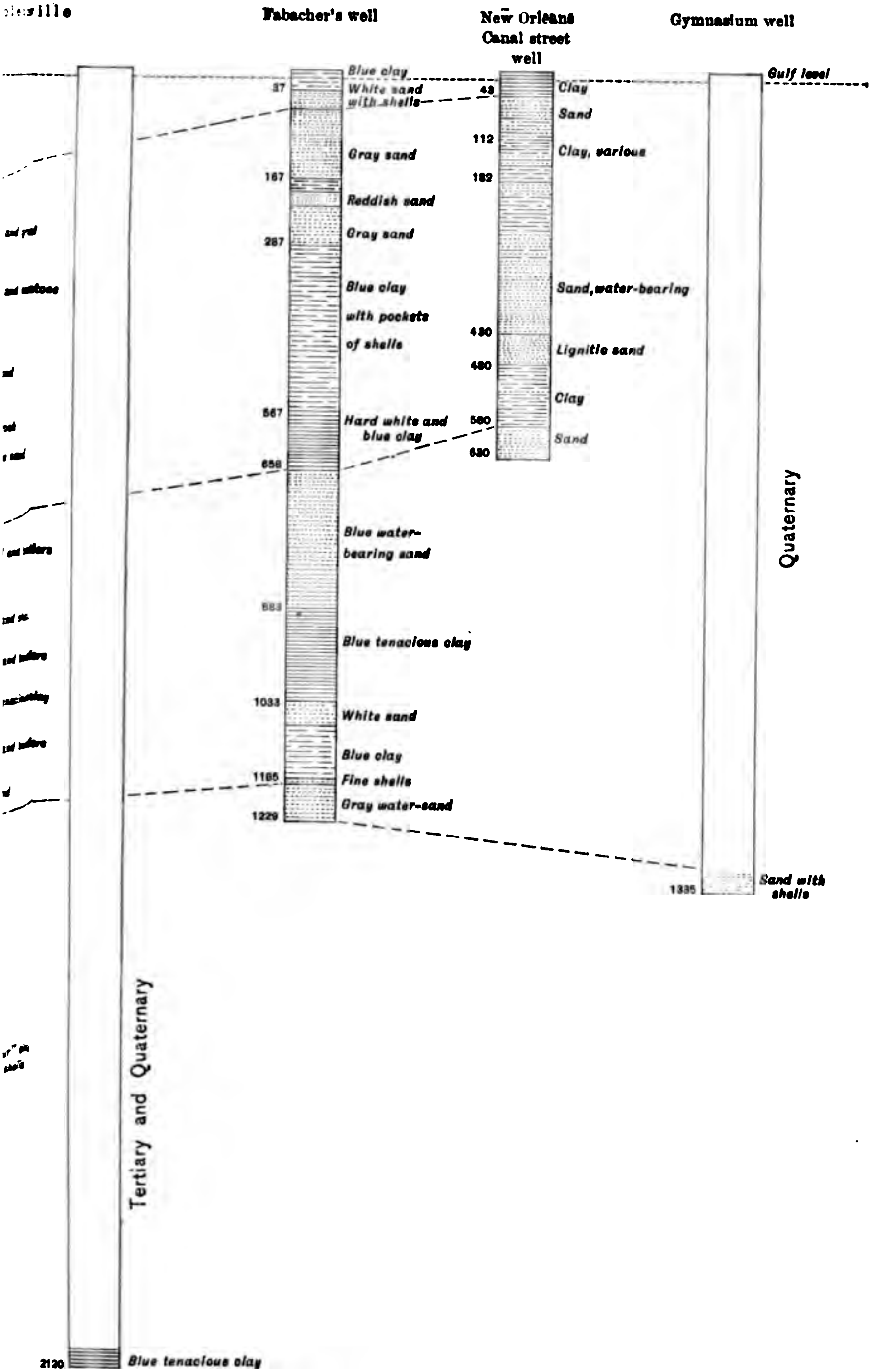
REGION OF PRAIRIES AND LOW, ROLLING HILLS

There is naturally no sharp line of demarcation between this topographic division and the one just described. The marsh and lake regions gradually become drier to the north, and the former Gulf, lake, or swamp bottoms assume the rôle of "crawfish" prairies. This is specially true of the low plains west of the Atchafalaya. In general, this region may be approximately defined as extending from the 20-foot to the 100-foot contour line. For a stretch of about 40 miles in width west of the Mississippi the general appearance of this region is somewhat changed by the erosion and the alluvial deposits of this great stream and its tributaries or distributaries. East of the Mississippi, however, the prairies again appear here and there, though the forests often descend to the very edge of the swamp lands. As the 100-foot contour is approached, the land becomes dissected by numerous small streams, and when cleared of its forest growth presents a decidedly rolling surface. East of the Mississippi the plains lying near the level of the 20 foot contour are still in places thickly studded with graceful, palm-like "long leaf" pines. Their years are numbered, though, as the many huge sawmill plants in their midst will attest.

The soil of the region or zone that lies nearly at the level of the 20-foot contour is decidedly clayey and "tight-bottomed," a feature of great economic importance to the rice planter. Farther up, toward the 100-foot contour, the soil is more sandy, and is, therefore, more pervious to surface waters. This, too, as we

LOUISIANA GEOLOGICAL SURVEY.




Fabacher's well
New Orleans Canal street well
Gymnasium well
Gulf level
Blue clay
37
White sand with shells
Gray sand
167
Reddish sand
Gray sand
287
Blue clay with pockets of shells
567
Hard white and blue clay
658
Blue water-bearing sand
883
Blue tenacious clay
1033
White sand
Blue clay
1185
Fine shells
Gray water-sand
1229
43
Clay
Sand
112
Clay, various
182
Sand, water-bearing
430
Lignitic sand
490
Clay
580
Sand
630
Quaternary
Sand with shells
1335
Tertiary and Quaternary
2120
Blue tenacious clay

shall see later on, is an extremely fortunate circumstance so far as the supply of underground water farther south is concerned.

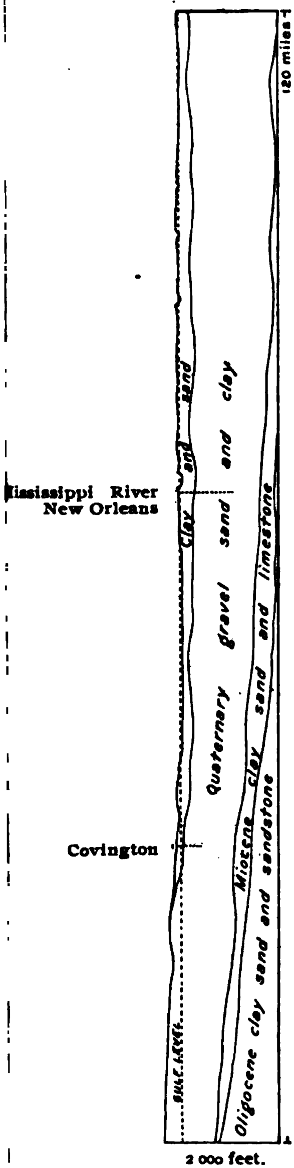


FIG. 3.—North-south section from the Mississippi line, through Covington and New Orleans and Barataria Bay, to the Gulf.

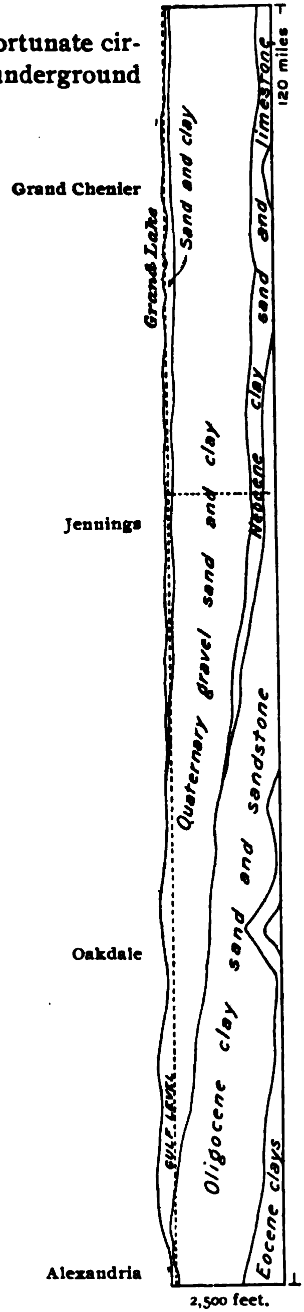


FIG. 4.—North-south section, starting 12 miles west of Alexandria, passing through Oakdale, Jennings, and Grand Lake, to the Gulf.

HILL LANDS

As the low lake and swamp lands pass gradually into the prairies, so the upper undulating prairie and timber lands pass gradually into the more abrupt dissected area. The chief difference to be noted is that in this last subdivision the streams are so numerous and their valleys so deep that there is little left of the old sea-bottom plain out of which this rugged topography was carved. As the surface of the land in this area rises from 100 feet to over 400 in a distance usually less than from the sea margin to the 20-foot contour, it is no wonder that the effects of erosion are well marked. Here the soil is still more gravelly or sandy than in the belt below the 100-foot contour. This fact, too, has much to do with the rapid erosion that is apparent on every hand. A small exception to the general appearance of these "long-leaf pine hill lands" is to be seen in the calcareous prairies (Anacacho) near Leesville, Vernon Parish.

STRATIGRAPHY OF SOUTHERN LOUISIANA

GENERAL CONSIDERATIONS

So far as underground waters are concerned, the stratigraphy of southern Louisiana is very simple, for nearly all of the wells discussed in this report are in very young or Quaternary deposits. Here and there, to be sure, peaks and uplifts of the older beds approach the surface, or even protrude above the general level of the land, but such uplifts are generally of extremely local nature. The Five Islands, for example, stretch along the coast for a distance of over 35 miles, but the greatest diameter of the largest one is only 2 miles. Again, these Five Islands are separated by a stretch of 25 miles from the truncated cone at Anse-la-Butte, or by 75 or 80 miles from similar structures at Sulphur and Vinton. The Cretaceous limestone of Bayou Chicot is 60 miles north of the northernmost island. There are doubtless other and undiscovered irregularities in the underlying rocks in southern Louisiana, but they are so evenly blanketed over by Quaternary clays and sands that there is no evidence of their existence.

The two cross sections herewith given show the general stratigraphy of the water-bearing sands in southern Louisiana (see figs. 3 and 4). Other sections can be constructed by placing in juxtaposition well sections that have been taken along some one general trend. On Pl. II is shown the stratigraphic relation of the beds encountered in well sections at Alexandria, Marksville,

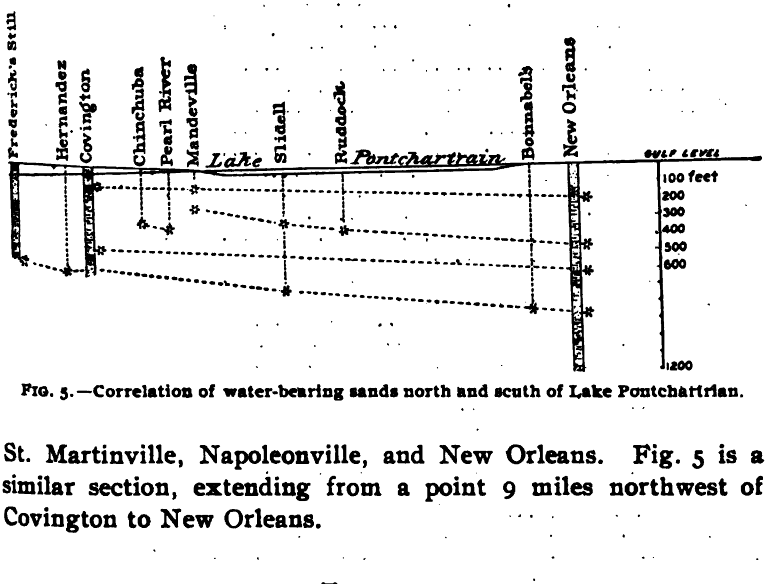


FIG. 5.—Correlation of water-bearing sands north and south of Lake Pontchartrian.

St. Martinville, Napoleonville, and New Orleans. Fig. 5 is a similar section, extending from a point 9 miles northwest of Covington to New Orleans.

TERTIARY

OLIGOCENE

In considering the Quaternary sands of this region, it seems proper to take some notice of the beds upon which they lie. Again, if the country around Alexandria, for example, be included in the region here called southern Louisiana, this discussion should embrace a consideration of the outcrops of Tertiary (Oligocene) rocks in that neighborhood, which are of considerable importance in connection with the supply of underground potable waters of the State. The well of the Alexandria Ice and Storage Company, recently put down, will give a fair idea of the character of the Oligocene (Grand Gulf) material in this part of the State. Its section is as follows :

Section of Well of Alexandria Ice and Storage Company, Alexandria, La.

	Thickness in feet.	Depth in feet.
Surface ground clay	21	21
Sand	2	23
Clay	15	38
Rock	27	65
Blue clay	88	153
Hard rock	2	155
Blue clay	20	175
Rock	8	183
Blue joint clay	145	328
Limestone	3	331
Clay	43	374
Hardpan	90	464
Hard limestone	2.5	466.5
Green clay	12	478.5
Hard rock	1.5	480
Blue clay	10	490
Sandstone	14	504
Clay	30	534
Sand	3	537
Rock	2	539
Clay	10	549
Sand	1	550
Clay	8	558
Sand	2	560
Blue clay	89	649
Sand	16	665
Clay	28	693
Sand	10	703
Blue clay	24	727
Soft sandstone	53	780
Clay	24	804
Sand	5	809
Soft sandstone	42	851
Clay	2	853
Sandstone	44	897
Sand	30	927

This well is provided with a 70-foot strainer, and before it was cleaned had a flow of 125 gallons a minute according to the report of a local paper.

The somewhat misleading information received at Alexandria three years ago regarding the material passed through in sinking the waterworks well caused us to improperly place the water-bearing sands here at a horizon that is manifestly far too low. The great thickness of the Grand Gulf beds here is surprising,

but the description of the material penetrated certainly places it in this division of the Tertiary.

The several fine flowing wells at Boyce are evidently mainly if not wholly in this horizon, though perhaps the one 810 feet deep which yields gas with the water, may have a somewhat lower origin than the shallower ones.

Similar water-bearing Grand Gulf sands on the Ouachita River near Catahoula Shoals have already been described.[a]

It is doubtful whether these beds have ever been encountered in drilling for water or oil farther south in Louisiana, except perhaps around some of the local upheavals or buried cones already referred to. The most probable exception is the Spring Hill oil well, not far east of Kinder, where, at a reported depth of 1,500 feet (probably about 1,200), the writer observed that the drill was passing through sharp quartz sand, mixed with flakes of green clay. It was reported that a soft sandstone, about 14 feet thick, was penetrated by the drill just before the writer's visit.

MIOCENE

There is little if anything in the stratigraphy of these rocks that concerns us here. Their position must be such (see figs. 3 and 4) that their water supply would be very uncertain, both as to quantity and quality. They probably contain salt water, and this has been found in them by many of the oil-well drillers. From samples of well borings already studied, it seems probable that where there are no local disturbances these beds in southern Louisiana, say along the thirtieth parallel, scarcely ever rise above a plain that lies 2,000 feet below sea level.

QUATERNARY

SUBDIVISIONS

The longer the geology of southern Louisiana is studied the more futile appears the attempt to make satisfactory subdivisions in the Quaternary deposits—subdivisions that have any definite time or structural limits. Differences in conditions of deposition during the same period of time have produced results that vary

[a] Report Geol. Survey Louisiana for 1902, p. 214

greatly in different localities. The same differences in conditions of deposition that we see to-day at different places in southern Louisiana, producing the sea-marsh clays with vegetable and brackish-water organic inclusions, the yellow sand ridges with an abundance of purely marine life, the purely fresh-water alluvium, and the alluvium intermingled with marine sands at the mouths of the larger rivers, all seem to have existed throughout Quaternary times. The mistake that has been made in assigning to the "Port Hudson group" a special place in geologic time may well be illustrated by the case of the casual theater-goer who drops in on a play on the last evening of the season and observes with care and interest the personæ, costumes, etc., throughout the different acts and scenes of the performance and afterwards records the fact that this particular play was given at this place at this particular time. The inveterate theater-goer, on the other hand, may see nothing of special interest in these facts, for he may know that that play had been running at that place not only that particular night but during the whole season. The swamp condition of the "Port Hudson" has been truly reproduced, with its clays, "black muck," and logs, to a depth of over 800 feet in the wells of southwestern Louisiana; the estuarian clay condition (Pontchartrain clay) is accurately reproduced at depths of 80, 500, 1,200, and is best of all at 1,800 feet beneath the surface; the marine sands may be found at various depths. Thick beds of so called Lafayette gravel are often interspersed with these "Port Hudson" elements.

It seems, therefore, that if there is anything to be gained by applying a name to clays that were evidently deposited in brackish water bays, estuaries, and lakes along the Gulf border, some such term as "Pontchartrain clays" may be used, with the understanding, however, that the name shall denote a particular kind of deposit or phase of deposition having no special time value. So, too, the deposits, mainly alluvial, containing a large amount of vegetable matter, especially stumps and trunks of trees, may, if necessary, be classed as Port Hudson clays; and marine sands may be referred to as Biloxi sands; but in all cases the terms must be understood as denoting mere phases of deposition, not stratigraphic units.

But the names that may be applied to the different portions of the Quaternary deposits of this State are of little importance so far as the present work is concerned. The important facts are these: Pervious material, such as sand (coarse and fine) and gravel, alternate with impervious clay beds of various thicknesses throughout the Quaternary deposits of southern Louisiana; these beds vary greatly as regards inclosed organic remains and products of decomposition and in different localities are inclined at different angles, the "dip" being, roughly speaking, in the same general direction as the slope of the surface of the land, though somewhat greater in amount; the character of the water is greatly modified by the medium through which it passes; the position or state of the water, i. e., whether "deep well" or "artesian," is dependent largely on local topography.

In the generalized sections here given, running north and south across this portion of the State (see figs. 3 and 4), no attempt has been made to show the many and various clay, sand, and gravel beds that form the Quaternary series of this region. The fact has been indicated, however, that generally, where the land is flat and erosion has been slight. the latest (uppermost) layers consist of fine sand and clays.

GENESIS OF DEPOSITS

The statistics upon which the above-mentioned general statements are based are mainly of two kinds—first, well sections and the fossils and rock material accompanying them, and second, facts noted in a somewhat detailed study of present areas of deposition along the southern border of the State. Well statistics will form an important section of this report. Their interpretation, however, depends on an accurate knowledge of present conditions of sedimentation. The following remarks and illustrations will therefore serve to throw light on the general statements already made and give a meaning to the detailed well records which follow.

The shore line of southern Louisiana is generally sandy, and there are often sand and shell ridges extending for miles parallel to the shore, either in close proximity to the Gulf or some distance inland. Those more distant from the present southern border of the land often show axial directions not in accord with those

nearer the Gulf, as may be seen by observing the direction of the ridges toward the eastern portion of Pecan "Island." These peculiar forms are not due to any considerable extent to erosion. Ridges of the same character are now being formed along the Gulf border, just above and just below mean tide. Off Cameron and Mud lakes, for example, one can see how, during storms, the waves have beaten up the sand and shells in ridges rising in some places to a height of 10 feet above mean tide. Out in the Gulf some distance from the land the same force is at work making the Sabine Shoals (see Pl. I.) The curve of Point au Fer, off Atchafalaya Bay, gives a strong hint as to the formation of ridges with a trend somewhat at variance to the general direction of the shore line. Isle Derniere, Timbalier, Ship, and Cat islands, and the Chandeleurs will probably become inland ridges like Pecan and Grand Chenier, in southwest Louisiana, or like the less elevated and less conspicuous shell ridge encountered in sinking the foundation for pumping station No. 7 for the drainage of New Orleans.

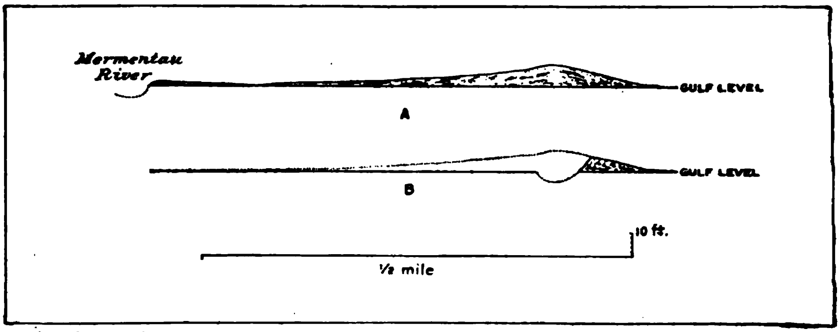


FIG. 6.—Sections across Grand Chenier Island; A, 3 miles west of village; B, one-half mile west of village.

The dimensions and general character of these ridges are well shown by fig. 6A. Pl. III, *A*, taken from the Louisiana report of 1902 (op. cit., Pl. IX), shows Mermentau River flowing in a westerly direction for some distance before it finally breaks through the ridge on its way to the Gulf. To the right the sea marsh stretches away to the east and south, with its waters practically at Gulf level. At the border of the Gulf, another though less important ridge is being formed at the present day. This

A. REMNANT OF GRAND CHENIER RIDGE AT THE FERRY LANDING ON MERMENTAU RIVER

B. LOCATION OF SPRINGS AMONG THE LIVE OAKS ON THE BORDER BETWEEN THE SEA MARSH AND THE SOUTH SIDE OF GRAND CHENIER ISLAND ABOUT 2 MILES EAST OF THE VILLAGE

(From Water Supply Paper, 101, U. S. Geol. Surv.)

A. NORTH SIDE OF GRAND CHENIER ISLAND

The Mermentau River in the background to the right, near the trees

B. SOUTH SHORE OF LAKE PONTCHARTRAIN, 1½ MILES WEST OF WEST END

Black clay soil with occasional heaps of white weathered *Rangia* shells.
(From Water Supply Paper, 101, U. S. Geol. Surv.)

statement, however, is not meant to imply that the large ridge shown in Pl. III, *A*, is of any other than late Pleistocene origin. In fact, the white objects shown in the foreground of the view are remains of large molluscan species similar to those now living in the Gulf and along the Atlantic coast. Notice should be taken of the fact, however, that these shells are all of marine origin. The few *Rangia* mixed with them show considerable river and wave erosion, and have evidently been washed into this marine assemblage by Gulfward flowing streams.

The sands and shells forming these ridges absorb enough rain water to furnish a continuous supply to many springs that flow out at sea level on either flank. Pl. III, *B* shows the location of such springs along the line of and between the great live oaks that have given the name of Chenier to this island.

The abrupt transition from the firmer ridge material to the softer marsh ground to the south is well shown by the fact that the aged oaks nearly always incline toward and finally fall into the marsh (to the left in the plate). In drilling for water similar abrupt changes are often met with in wells but a short distance apart.

On the north or opposite side of the ridge, scarcely three-fourths of a mile away, the character of the vegetation and deposition is very different (see Pl. IV, *A*). The marshy land is less even or is slightly undulating, showing accordingly all stages of transition from moist to wet lands through occasionally inundated swamps to areas nearly always beneath the water. These areas are receiving sediment from the flood stages of the bayous and hence are gradually filling in and presumably rising, irrespective of any uplifting movement that may be affecting the coast as a whole.

Such areas explain the way that the deposits encountered in the various wells to the north were formed. The occurrence of decayed leaves, wood, fresh-water and land shells, together with fragments of marine shells in many borings, thus receives a natural explanation.

Equally interesting and important in the formation of this portion of the State are the shallow lakes, reference to which has been made in discussing fig. 2, such as Sabine, Calcasieu,

Grand, White, Maurepas, Pontchartrain, and Borgne lakes, as well as the bodies of water called bays simply because they are not so completely surrounded by land. Of these bays Vermilion, Côte Blanche, Atchafalaya, Caillou, Terrebonne, Timbalier, as well as the still more open Chandeleur and Mississippi sounds, are good examples. In these there is a complete series of beds showing transition from purely marine to brackish or even fresh water. The fulgurs, naticas, arcas, oysters, tellinas, and mactras in the open sounds give place in the more inclosed bays to oysters, mactras, and rangias, while in the still more inland lakes the rangias lose their fellowship with the salt-water forms and live in comfort and harmony with the purely fresh-water unios. This condition may be seen in Lake Charles, a small swelling in Calcasieu River about 6c miles from the coast.

Marks of wave action and heaps of brackish-water *Rangia* shells may be seen along the low shore of Lake Pontchartrain, shown in Pl. IV, *B*. The characteristics of this vast expanse of shallow brackish water deserve more than passing notice by one who would understand the general geological history of southern Louisiana. It would scarcely be an exaggeration to assert that during some period of Pleistocene time practically all of the land area of this part of the State passed through a Pontchartrain stage. By this it is not meant that the whole of this area was one great brackish, inland lake at the same time; far from it. There are now in this region open sounds, more inclosed bays, still more landlocked lakes, growing smaller, usually, the farther inland the body of water lies. North of Lake Charles there is an extensive swamp area that has the appearance of being an old lake bed from which the waters are nearly drained off. Little Lake Charles is a remnant of a corner of this former extensive body of water. Still farther up are The Bays, low, flat, level, hard, wet-bottomed areas, embracing several thousand acres of land. The water and oil wells that have been drilled during recent years in southern Louisiana seldom fail to encounter masses of *Rangia* shells at some depth. Water wells, at Jennings for example, sometimes pass through a bed of such shells 10 feet thick, lying at depths ranging from 50 to 100 feet below the surface. On the shores of Lake Charles, Lake Arthur,

Grand Lake, Berwick Bay, Lake Pontchartrain, and elsewhere in countless localities the same recent *Rangia* can be seen heaped up in ridges. At Jennings again similar Pontchartrain clays, with the same *Rangia*, are generally encountered just above the oil in wells, at a depth of about 1, 800 feet.

EFFECT OF THE MISSISSIPPI ON STRATIGRAPHY OF SOUTHERN LOUISIANA

The Quaternary material of Louisiana was evidently brought to its present place by Mississippi River and other smaller streams emptying into the Gulf, as it then was, throughout a stretch of perhaps 250 miles. In Tertiary as well as Quaternary times the Mississippi has had a marked influence on the character of deposition and the character of life to be found in this section. In several stages of the Eocene the deposits along the Mississippi axis are decidedly lignitic; farther to the east and west they are more marine. Certain stages in the Oligocene show similar conditions and differences. It must not surprise us, then, to find that the greater part of the Quaternary deposits of southern Louisiana are composed of beds that bespeak clearly the proximity of brackish or fresh water or land conditions. We attribute the presence of tenacious clays in the wells of southern Louisiana, to a depth of 1,800 feet in places, indirectly to the rapid filling in of the Gulf border by the Mississippi sedimentation. In some places there has been a continual loading and consequent depression of the Gulf's border; this has given rise to uplifts in regions not far distant. The shifting of the mouth of the river and the consequent change of loading point has caused a shifting of regions of depression and upheaval. If the region of uplift is some distance from the coast, then shallow sounds, bays, or lakes result, according to the extent of the uplifting. These, when finally filled with Pontchartrain clays derived from the sediment of inflowing rivers, pass through the sea-marsh stage into "crawfish" prairies, when the region in which they occur has been elevated a few feet.

Wave action, to be sure, performs a significant part in the formation of certain ridges that will eventually act as temporary borders to these landlocked bodies of water; but, after all, it is

mainly the action of the Mississippi that causes the many changes of level that are so well recorded in the Quaternary deposits throughout south Louisiana.

In the immediate vicinity of the present course of the larger rivers, especially the Mississippi, Biloxi conditions can scarcely be expected to prevail. Here and there will be ridges of sand containing a purely marine fauna, but they will be notably local. Perhaps no better example of such a marine oasis in beds generally of a somewhat brackish water origin can be referred to than the sands containing beautifully preserved seashells at pumping station No. 7 of the New Orleans Drainage Works. This is evidently one of those ridges caused by wave action and slight upheaval that have served to cut off portions of the Gulf in the manner described above. The mouth of the Mississippi was at that time doubtless as far up as Bayou Sara, and its waters would not materially modify the life at a point then so far out at sea. So, too, at Napoleonville, the fauna at a depth of 2,100 feet seems purely marine. When this fauna lived doubtless the mouth of the Mississippi was as far north as the point named above, hence no great modification was brought about by the fresh waters of that great stream. Later, however, the fauna became brackish, with a preponderance of *Rangia* at 1,200 feet, and the drillers brought out a large tooth, equine in appearance, from a depth of 800 feet. Large quantities of *Rangia* have been found in a well near Morgan City at a depth of about 500 feet, and specimens of the same species were obtained at 400 feet at the Istrouma Hotel well at Baton Rouge.

SUBDIVISIONS OF SOUTHERN LOUISIANA, BASED ON UNDERGROUND WATER CONDITIONS

MODIFICATION OF KIND AND CONDITIONS OF WATER BROUGHT ABOUT BY LOCAL TOPOGRAPHY AND STRATIGRAPHY

For a somewhat detailed exposition of the topographic features of the southern part of Louisiana the reader is referred to the map herewith published as Pl. I, but a clearer and more general idea of the subject can be obtained more quickly by referring to fig. 1. Topography alone may have little bearing on the subject

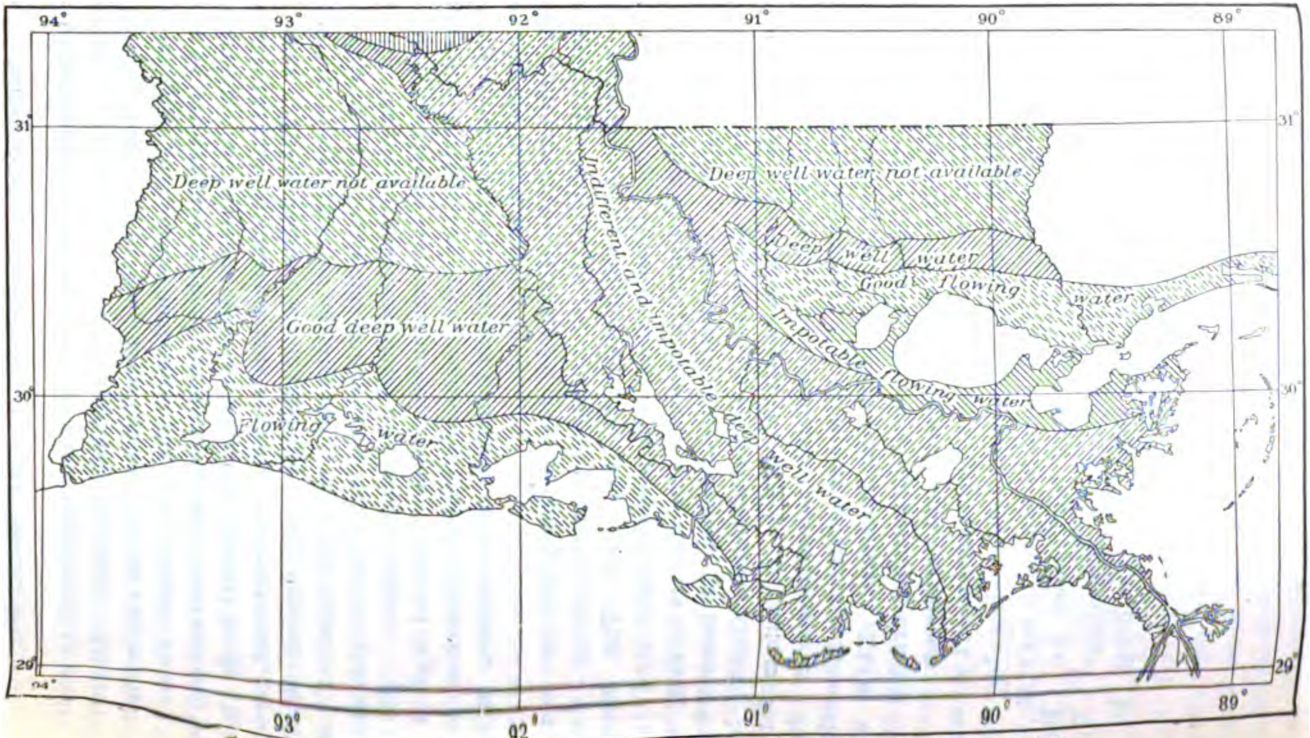


FIG. 7.—Subdivisions of southern Louisiana in accordance with the underground water conditions.

of underground water supplies, but when considered in connection with stratigraphy its significance may be great. Where the different formations or beds slope coastwise at an angle slightly greater than that of the surface of the land, where there are more or less extended beds of pervious material alternating with impervious, and where there is an abundant rainfall back in the country the conditions are favorable for an underground supply of water. The pressure head of this supply will depend largely upon the topography and stratigraphy, while the kind of water will depend upon the kinds of rock the water has to penetrate and the length of time consumed in its penetration. Kind of water is, therefore, indirectly more or less influenced by topography and stratigraphy. As a result of all these influences underground water occurs in southern Louisiana approximately as indicated by the accompanying fig. 7.

The influence of topography on pressure head will be evident to anyone who will study the outline cross section given in fig. 8 in connection with the topographic map, Pl. I. The section extends from Pearl River to Oberlin, passing through Covington, Hammond, Baton Rouge, Opelousas, and the country lying westward, to Oberlin. The situation at Opelousas is interesting. Here the surface of the ground is 67 feet above the Gulf level, but water rises only 22 feet above that level. A glance at the topographic map will show the cause of this low pressure head. Northward, in the direction of the uprising strata or bedding planes, there is no higher ground than at Opelousas. The water there present must work sidewise along the pervious strata from the somewhat distant hill land lying west and northwest. East of the Mississippi the conditions are different, for only a few miles east of Baton Rouge the pressure head is considerably above the surface of the ground, the hill land to the north being close by. The marked decrease in pressure head shown at Baton Rouge is evidently due to the nearness of the Mississippi River Valley. Doubtless, too, this same valley has something to do with the low stand of the water at Opelousas.

Lesser depressions than the Mississippi Valley have their influence on the head of subterranean waters, as may be seen by the section along the line of the Southern Pacific Railroad from Lafayette west, shown in fig. 9. Mermentau River, with its tributaries, has degraded this central portion of southwest Louisiana, and the pressure head of the deep-well waters responds to this topographic feature. Calcasieu River seems to have the opposite effect on the pressure head about Lake Charles. Here, however, we are dealing with a region that is immediately south of some of the highest land in the State, and it is doubtless this condition that counteracts any reverse influence the Calcasieu Valley might possess.

East of the Mississippi, in the neighborhood of New Orleans, the low pressure shown by the various water-bearing layers penetrated in wells less than 1,300 feet deep is probably due to the wide, low stretch just to the north—i. e., the Lake Pontchartrain depression. On Ship Island good water flows freely, and with much more force than is exhibited by the New Orleans wells. The narrowness of Mississippi Sound, as compared to Lake Pontchartrain, offers a ready explanation of this fact.

REMARKS ON SPECIAL AREAS

On the small map (fig. 7) there is indicated a small artesian area about Alexandria. The extent of this area must of necessity be very limited, for the Grand Gulf formation usually dips rapidly Gulfward, so that the water-bearing strata would soon be below practicable depths so far as ordinary water supply and irrigation are concerned (see stratigraphy indicated by fig. 4).

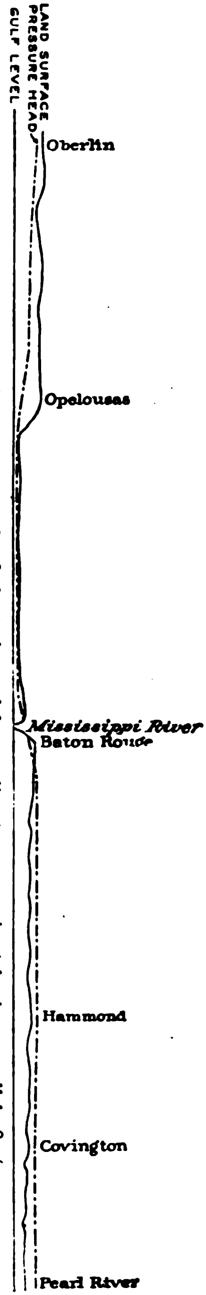


FIG. 8.—Relations of land surface to pressure head of artesian and deep well waters approximately along parallel 30° 17'.

To what extent water would flow close to the Gulf border from Sabine River to Atchafalaya Bay can scarcely be conjectured, though from the fact that in the neighborhood of Lake Charles, Gueydan, and places farther east fairly good water does flow from wells not over 200 feet deep, one may expect to find some kind of artesian water all along the coast in the region mentioned.[a]

North of the artesian area lying north of Lake Pontchartrain a belt of country has been marked on fig. 7 as a probable deep-well area. As water in this region will flow readily from wells situated at elevations between sea level and the 50-foot contour, or even above the latter in some instances, there seems to be no reason why it will not rise to the surface or to points between the surface and 50 feet below the surface at localities situated at elevations lying between the 50 and 100-foot contours.

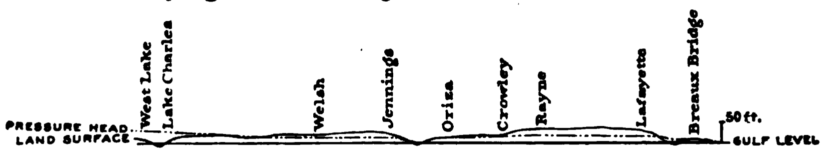


FIG. 9—Relation of land surface to pressure head of artesian and deep-well waters approximately along parallel 30° 12′.

Mammoth Spring, near Franklington, Washington Parish, would lead one to suppose that deep wells may eventually prove successful in some parts of these northern parishes where on the small map (fig. 7) no sign of the fact is indicated.

So far as the other areas are concerned, little need be said. The deep-well area in southwest Louisiana is well understood. Sand and gravel beds that seem saturated with water are encountered at various depths, ranging from 150 to 500 feet. Near the coast the water overflows; farther northward as a rule it stands lower and lower below the surface, so that north of Oberlin the expense of lifting water to the surface would more than equal the profits of irrigated crops. The map (fig. 7) does not indicate that no deep-well water can be found in much of the northern region. It implies rather that such waters would generally stand say 30 or more feet beneath the surface of soil; and hence their value for irrigation and general purposes would be materially lessened, owing to the increased cost of pumping.

[a] Good water has recently been obtained in this region.—G. D. H., April, 1904.

WELL STATISTICS

ARTESIAN WELLS IN SOUTHERN MISSISSIPPI, FROM BILOXI WESTWARD

This part of Mississippi is justly famous for its fine artesian wells. Not only does the water seem good and wholesome, but the pressure is strong and the supply is ample.

As will be seen from the statistics given below, there are shallow sands from which pumping water may be had, and deeper ones from which a fair quantity of flowing water may be obtained, but as a rule the best wells are sunk to a much greater depth here than in southern Louisiana.

HARRISON COUNTY

BILOXI

Section of well one-half mile east of railroad station

(Section by Brown)

Soil	Thickness in feet	Depth in feet
Soil and clay	4	4
Sand, bearing good pumping water	61	65
Whitish clay	35	100
Greenish clay	390	490
Sand, extremely fine at first, becoming coarser, below coarse gravel	428	918

Pipe six and four inches; flow at surface of the ground, 1,000 gallons per minute; 500 gallons at elevation of 35 feet, 250 gallons at elevation of 55 feet. This indicates that the pressure head is not far from 75 feet above tide.

City waterworks wells.—No notes were obtained regarding the depths of these wells. It was observed, however, that the large 6-inch pipes carried the water up rapidly and filled the elevated tanks to a height of 40 feet above the general surface of the ground.

Ice-factory wells.—At these wells the difference in temperature of the shallow and deep well was specially noted, viz.: Water (flowing) from 500-foot stratum, 79.5° F.; from 900-foot stratum, 82.5° F.

SHIP ISLAND

Quarantine station well.—Depth, 630 feet; mouth of well about 10 feet above tide.

Section of well at Quarantine station, Ship Island

(Section by Dr. P. C. Kallock)

Soil	Thickness		Depth	
	Feet	*In.*	*Feet*	*In.*
White sand	45	0	45	0
Soft clay and mud	155	0	200	0
Hard blue clay	100	0	300	0
White sand	5	0	305	0
Blue clay	60	0	565	0
Sandstone		5	565	5
Blue clay	156	0	721	5
Water-bearing sand	9	0	630	5

Light-house well.—Mouth of well perhaps 10 feet above tide; flow, vigorous; estimated at 50 gallons per minute from a 2-inch pipe; depth, 750 feet.

Section of well at light-house on Ship Island

(Section by Dr. Murdock)

Soil	Thickness in feet	Depth in feet
Sand	250	250
Yellow clay	100	350
Blackish mud	50	400
Fine sand, with shells	50	450
Blue clay	250	700
Water-bearing sand	50	750

MISSISSIPPI CITY

C. Clemenshaw's well.—Depth, 925 feet; mouth of the well about 18 feet above tide. Regarding the well Mr. Clemenshaw remarks:

Passed through no hard rock, no quicksand, but clay and blue sand, the latter often highly micaceous. A 60-gallon per minute flow was found at a depth of 600 feet, a 200-gallon flow at 925 feet.

E. P. Ellis's well.—Depth, 850 feet; 3-inch pipe; flow, 80 gallons per minute; 55 feet above tide.

Court-house well.—Pipe, 2½ inches; reduced to 1½ inches; flow, 20 gallons per minute; 28 feet above ground, or about 50 feet above tide.

GENERAL SECTION FROM PASS CHRISTIAN TO BILOXI

According to Mr. A Dixon, who has accompanied a well-drilling outfit for several years in this part of the State, the majority of the wells show approximately the following section:

General section of wells between Pass Christian and Biloxi

Soil	Thickness in feet	Depth in feet
Sand	80	80
Clay	....	125
Sand and clay	....	425
Light-gray fine sand	....	500
Clay	....	600
Water-bearing sand	....	685

BAY ST. LOUIS

Mr. N. H. Darton[a] gives the following data for this locality:

Many wells; temperature of deeper, 78°; depth, 400 to 600 feet; size, from 2 to 4½ inches; yield per minute, 100 to 105 gallons.

ARTESIAN AND DEEP WELLS IN LOUISIANA EAST OF THE MISSISSIPPI

ST. TAMMANY PARISH

COVINGTON AND VICINITY

Court-house well.—In yard in front of the court-house; April, 1901, flow, 2½ gallons per minute; temperature, 73° F.; June 26, 1903, flow, 1 gallon per minute; temperature, 72.4° F. Elevation of ground, 32 feet; of flow, 35.6 feet above tide.

Dixon Academy well.—One-half mile west of Covington; pipe, 2½ inches; flow, 25 gallons per minute, 1901; temperature, 72.6° F., June 26, 1903; elevation of flow, 26.7 feet above tide.

Dummet well.—On Homesville road; depth, 572 feet; pipe, about 2 inches; flow, according to driller, Robert Wallbillick, 1901, when first put down, 2 feet from ground, 21 gallons per minute. Record by G. D. Harris, 1903, 15 gallons per minute, about 3 feet above ground; temperature, 74° F.

[a] Water-supply and Irrigation Paper No. 57, 1902, United States Geological Survey.

Section of Dummet well, St. Tammany Parish

(Section furnished by Mr. Wallbillick)

	Thickness in feet	Depth in feet
White clay	15	15
Yellow clay	6	21
White clay	35	56
Coarse white sand	25	81
Fine gravel	12	93
Coarse white sand	6	99
Coarse white sand and gravel	14	113
Coarse yellow sand and gravel	6	119
Coarse yellow sand	8	127
Gravel	10	137
Red clay	1	138
Gravel	10	148
Red clay	2	150
Gravel	10	160
Red sand and gravel	20	180
Gravel	32	212
Red sand	38	250
Coarse gravel	25	275
Coarse white sand	4	279
White clay	18	297
Blue clay	183	480
Fine bluish and greenish water-bearing sand	7	487
Blue clay	71	558
Gray sand	6	564
Fine blue and greenish sand	8	572

John Dutch's well.—In north-central part of Covington; depth, 600 feet; flow, 20 gallons per minute; temperature, 74° F., April 17, 1901; elevation of flow, 35.6 feet above tide.

Mrs. Flower's wells.—These records were furnished by Mr. Wallbillick, and show that here, as elsewhere, there are sandy strata bearing water at far less depths than the beds furnishing the water that will flow above the surface of the ground. Such wells are termed shallow or pumping wells.

Sections of Mrs. Flower's wells, St. Tammany Parish

	Thickness		Depth	
	Ft.	*in*	*Ft.*	*in.*
Well No. 1:				
White clay	30	6	30	6
Blue clay	18	6	49	0
White sand	2	0	51	0
Blue clay	17	0	68	0
Shells mixed with blue clay	1	6	69	6
Fine white sand	27	6	97	0
Coarse white sand (pumping stratum)	6	0	103	0
Well No. 2:				
White clay	40	0	40	0
Blue clay	2	0	42	0
White clay	21	0	63	0
Shells mixed with black clay	0	6	63	6
Dark clay	9	6	73	0
White sand	21	0	94	0

These wells are but 300 feet apart.

H. Haller's well.—Southwestern part of Covington; depth 520 feet; pipe, 2 inches; flow, 30 gallons per minute; temperature, 72° F., June, 1903.

Hernandez place, well by house.—About 2 miles north of Covington; depth, 610 feet; pipe, 2.5 inches; flow from 1-inch pipe, January, 1901, 38½ gallons per minute; April, 1901, (from whole pipe?), 60 gallons per minute; temperature, 1901, 73° F.; elevation of ground, 46.1 feet above tide; top of basin, 47.3 feet; of pipe, 48.5 feet.

Hernandez well, by barn.—About 2½ miles north of Covington; depth approximately as in last well; pipe, 2½ inches; flow January, 1901, 35⅓ gallons per minute; March, 1902, 54⅓ gallons per minute; June, 27, 1903, 40 gallons per minute; temperature, 72.25°; elevation of ground, 47.4 feet; of pipe, 52; pressure head considerably above 60 above tide.

This is the well shown in Pl. V, *A*, and is usually considered one of the best in this part of the State, but it has not the capacity of the well by the house, which is so piped that satisfactory measurements of its flow are hard to obtain. This

beautiful summer residence is now the property of Louis P. Rice, of Covington and New Orleans.

Ice factory wells.—Three wells of the "shallow" type before mentioned, two 2 inch and one 2½-inch, furnish, when pumped, sufficient water for the ice factory. The water rises to within about 8 feet of the surface.

Lyon well.—At Claiborne, 1 mile east of Covington; depth, 630 feet; pipe, 2 inches; flow, 30 gallons per minute; temperature, 73°, April, 1901; flow, 26 gallons per minute; temperature, 74°, June 26, 1903; elevation, 26.6 feet above tide.

Maison Blanche.—Depth, 480 feet; pipe, 2 inches, reduced to 1 inch; flow per minute, April, 1901, 20½ gallons; March, 1902, 23½ gallons; June 25, 1903, 16½ gallons; temperature, 72.25°; elevation of ground, 31 feet 6 inches of top of basin, 33.6 feet of flow, 35.5 feet above tide.

Other wells.—There are many other flowing wells about Covington, but the data presented above will give a fair idea of their general character. It will be seen that as the depth increases the temperature also increases, as might well be expected. For a 600-foot well a temperature of 74° is about normal here. Compare these in this respect with the Hammond and Ponchatoula wells.

There is a flow about Covington, at present, within a radius of 3 miles, of about 300 gallons per minute; and as is generally the case the water is mainly wasted, i. e., allowed to flow to no purpose.

ABITA SPRINGS

Abita Hotel and Cottage Company well.—Half mile east of Abita Springs Station (elevation of station, 38.3 feet above tide); depth, given by some as 545, by others, 525 feet; pipe, 2 inches; flow through stopcock, 54 gallons per minute; temperature, 73°; no screen. This is a new well, put down this season (1903). When allowed to flow freely it reduces the pressure of neighboring wells materially, especially to the west and south.

Aubert Hotel well.—About one-third mile southeast of station; depth, 585 feet; pipe, 1½ inches; flow from a faucet, 2½ feet above the ground; 38.3 feet above tide January, 1901; 12½ gallons per minute through a network of pipes 60 feet long;

June 26, 1903, 22 gallons per minute, direct from well at a height of about 38 feet above tide.

See analysis given below. Pressure head at least 50 feet above tide.

Frank Brinker's well.—One-fourth mile northwest of the station; pipe, 2 inches; depth, 574 feet; flow through stopcock about 2 feet above the surface of the ground, 27 gallons per minute; no screen; temperature, 73° F.

Labat Hotel well.—One-fourth mile north of the station; depth, 526 feet; pipe, 1½ inches; original flow, seven or eight years ago, said to be 45 gallons per minute; flow, January, 1901, from faucet, 45.2 feet above tide, 37 gallons; flow from pipe with stopcock but without faucet, June 26, 1903, 56 gallons per minute; temperature, 74°. When the size of the pipe is taken into consideration this is the most freely flowing well in St. Tammany Parish.

Chas. W. Schmidt's well.—A few yards south of the station; depth supposed to be 800 feet; pipe, 1½ inches; flow through a one-half inch faucet, in 1901 and 1903, 4 gallons per minute; temperature, 72°; elevation of ground, 35.6 feet; of faucet, 36.6 feet above tide. This was perhaps the earliest artesian well in this vicinity. It was not decidedly successful, doubtless on account of the novelty of the undertaking. The temperature indicates that its flow of water comes from a depth much short of 800 feet.

Simon's Hotel well.—Just east of the station; hotel building burned; pipe, 1½ inches; flow through two elbows and a horizontal pipe 2 feet in length, January, 1901, 12 gallons per minute; April, 1901, 11 gallons; June, 1903, 10 gallons; temperature, 1901, 72°; 1903, 73°; elevation of ground, 38.3 feet of top of basin, 41.7 feet of top of pipe, 43.6 feet above tide.

Limit of supply.—The present flow of water from artesian wells about Abita Springs is not far from 200 gallons per minute. The sensitiveness, especially on the part of the smaller wells, to the flow from the new, large well would seem to indicate that the supply, though ample for all legitimate uses, should not be unduly drawn upon, else pumping in some instances will have to be resorted to.

PEARL RIVER JUNCTION

When compared with most of the wells in this part of the State the well at Pearl River Junction appears remarkable for the great amount of water it furnishes at a shallow depth. The water is not regarded as suitable for boiler and drinking purposes, though for common household uses it serves excellently. Depth, 350 feet; pipe, 2½ inches; flow through a stopcock at the rate of 72 gallons per minute; flow from open 2½-inch pipe said to be 90 gallons per minute; pressure head, 54 feet above tide. The elevation of station is 31 feet above tide.

MANDEVILLE JUNCTION

At Mandeville Junction there is an excellent well that furnishes the railroad tank with water, flowing up freely 27 feet above the ground. Since no levels have ever been run over this road it is not possible to state the exact height of the well above tide.

MANDEVILLE

The elevation of station at Mandeville is 6.8 feet above tide.

Dessome well.—Northeastern part of the village, in flower garden; depth, 217 feet; pipe 2 inches; flow per minute, March, 1901, 28 1 gallons; March, 1902, 26 gallons; June 27, 1903, 28 gallons; temperature in 1902, 69.5°; in June, 1903, 69 8 F. Flows from pipe 9 feet above tide; pressure head, 14½ feet above tide.

Mrs. John Hawkins's well.—Western part of the village; pipe, 2 inches, reduced to 1¼ inches; flow per minute, 1902, 40 gallons; in 1903, 13 gallons; temperature in 1902, 68.5°; in 1903, 70° F. Flow from a pipe 7.35 feet above tide.

C. H. Jackson's well.—Depth, 135 feet; pipe, 1½ inches, reduced to 1 inch; flow, 0.97 gallon per minute; height of flow, 13.8 feet above tide.

Dr. Paine's well.—Flow, open 2-inch pipe, 10.6 gallons per minute; reduced to 1 inch, 10½ gallons per minute; through inch pipe with stopcock attached, 9.1 gallons per minute. Elevation of ground, 3.85 feet; of flow, 6.80 feet above tide.

Ribava well.—Depth, 247 feet; flow, from open 1¼ inch pipe, 12 gallons per minute, 1901; through stopcock, 9¼ gallons per minute in 1902; through stopcock, 1903, 7 gallons per minute;

A. Well in Barn Lot of the Hernandez Place, 2½ Miles North of Covington, La.

B. Well in Mr. Anderson's Barnyard, Three-Fourths of a Mile North-west of Hammond Station, La.

(From Water Supply Paper, 101, U. S. Geol. Surv.)

temperature, 71°, February, 1902; 72°, June, 1903; elevation of ground, 3.42 feet; of flow, 4.9 feet above tide.

Rush well.—North of station, perhaps one-third mile; depth, 252 feet; pipe, 2 inches, reduced to 1 inch; flow, 7 gallons per minute; 4 feet above the general level of the ground.

Depths.—As in several other regions already described, there are here to be found beds yielding water at a depth considerably less than that attained by most of the artesian wells. The water in the shallower wells usually stands, in the vicinity of Covington, as well as about Hammond, from 2 to 10 feet below the surface. Here such shallow wells, about 90 feet deep, actually flow, though not vigorously.

It will be noticed that the wells about Mandeville are very much shallower than at Covington, 9 miles to the north. They are about 3° cooler, and have a less ferruginous taste and appearance. The wells about Slidell have not been examined, but Mr. Blakemore, of New Orleans, says that there the Mandeville water (300 feet), and a decidedly bad "yellow" water (perhaps 700 feet down), are met with. The latter is described as the same water that is found at the same depth in the city of New Orleans.

CHINCHUBA

Depth, 325 feet; pipe 2 inches; flow reduced to one-third inch pipe, hence with pressure head of but 7.3 feet; temperature, 72° F.; elevation of ground, 19 feet above tide.

Other wells at a brickyard to the north, and at a locality 4 miles to the northwest, are reported to have satisfactory artesian wells, but they were not visited.

TANGIPAHOA PARISH

SINGLETRY'S STILL.

This well is about 9 miles northwest of Covington, or in the SW. ¼ NW. ¼ sec. 31, 5 S., 10 E. It is so distant from any other flowing well that the following statistics and section, though imperfect, will be of considerable interest to landowners and well men in this section of the State.

Section of well at Singletry's still

[Section given by E. P. Singletry]

	Thickness in feet.	Depth in feet.
Sand and clay	100	100
Quicksand	120	220
Red clay	170	390
Pipe clay	160	550
Blue sand	10	560

Depth, 560 feet; pipe, about 2 inches; flow, 18 gallons per minute, with several small leaks; height of pipe where measured, 78 feet above tide. (See analysis, p. 78.) The elevation was determined in 1901 by J. Pacheco and G. D. Harris, who run a spirit-level line out from Covington.

HAMMOND

The elevation of the railroad station at Hammond is 43.3 feet above tide.

Captain Anderson's well.—For general appearance of the well see Pl. V, *B;* depth, 272 feet; size, 2 inches; flow, 20 gallons per minute; temperature of water, 70.5°; strainer or point, 10 feet.

Section: Sand to 40 feet, a thick bed of blue clay, then sand and gravel to the bottom.

Well sunk and cased with galvanized pipe for 55 cents per foot; hence total cost of well, approximately, $150.

Baltzell & Thomas livery stable well.—Depth, 330 feet; size, 2 inches; temperature, 71.5°; flow, 24 gallons per minute, June 23, 1903; screen, 7 feet long.

B. F. Bauerle's well.—One and one-half miles south-southwest of Hammond; depth, 212 feet; size, 2 inches; temperature, 6?°; flow, June 23, 1903, 8¾ gallons per minute.

Durkee well.—Depth, 297 feet; size, 2 inches reduced to 1¼ inches; flow in March, 1901, 24 gallons per minute, besides two small distributing pipes that could not be closed; flow, same conditions, June 23, 1903, 24 gallons per minute.

Eastman well.—One and one-half miles south of Hammond; depth, 309 feet; pipe, 2 inches; flow, 30 gallons per minute, in

1901; pressure, 5½ pounds per square inch; temperature, 72° F.

Forbes well.—One mile east of Hammond, NE. ¼ NW. ¼, section 30; depth, 250 feet; flow, June 23, 1903, 7½ gallons per minute; size, 1½ inches; pressure head, 17 feet above surface of ground; age, 8 years.

Three water-bearing beds were encountered in sinking this well: (1) Depth, 52 feet, water coming to within 2 feet of surface; (2) 150 feet, coming to within 8 feet of surface; (3) 250 feet, with head of 17 feet.

Hermann well.—Two miles south-southwest of Hammond. Impossible to obtain accurate data, except pressure, 8½ pounds per square inch.

Hammond Ice Company's well.—Depth, 340 feet; pipe, 2 inches; flow in 1901, about 50 feet above tide, 15 gallons per minute; same conditions, June, 1903, 11 gallons per minute; temperature, both years, 72° F.

Hammond Mineral Water Company (Limited).—Well, 460 feet deep; pipe, 3 inches; flow, about 46 feet above tide, 65 gallons per minute.

C. H. Hommel's well.—One-half mile southeast of Hammond; depth, 318 feet; flow, impossible to measure now; said to have been, when well was first put down, 45 gallons per minute; temperature, 70.5° F.

Alfred Jackson's well.—Depth, 265 feet; pipe, 1¼ inches; flow, 3 feet above surface of the ground, June, 1903, 6¾ gallons per minute; temperature, 71° F.

June Brothers' sawmill well.—Depth, 377 feet; pipe, 2 inches; flow, at a point 5 feet above the ground, open pipe with one elbow, June 22, 1903, 24 gallons per minute; temperature, 71° F.

Kate well.—In western part of the village, on Morris avenue; size of pipe, 2 inches; free flow, perhaps 3 feet above the general surface of the ground, 30 gallons per minute, June 23, 1903; temperature, 70.6° F. A new well, just finished.

Fred Karlton's well.—One-half mile southeast of Hammond; depth, 302 feet; pipe, 2 inches below, reduced to 1½ above surface of ground; screen, 10 feet; flow, June, 1903, 24 gallons per minute; cost, $150; temperature, 70.5° F.

Kemp well.—Three-fourths mile southeast of Hammond; pipe, 1¼ inches; flow, June, 1903, 5 gallons per minute; temperature, 70° F.

Merritt Miller's well.—Depth, 265 feet; pipe, 2 inches, reduced to 1¼; flow in 1901, 28¼ gallons per minute; elevation of flow, 44 feet above tide; pressure head, 56.6 feet above tide; temperature, 71° F.

Morrison well.—Pipe, 2 inches; flow, 46 feet above tide, 1901, 20 gallons per minute; June, 1903, same flow; pressure head, 51.7 feet above tide; temperature, 72° F.

Oaks Hotel well.—Depth, 300 feet; pipe, 2 inches; flow, 25 gallons per minute; age, ten years; temperature, 71° F. See analysis, p. 75.

Oil well.—The following section was obtained from samples in 1901:

Section of oil well at Hammond, Tangipahoa Parish

	Depth in feet
Clay	45–55
Sand and gravel	85–100
Yellow loam	173
Water-bearing sand	294
Coarse sand	368
Coarse sand and gravel	475
The same, more sandy	500–512
5-foot bed of hard blue clay, about	570
"Pepper and salt sand"	570+

The new well, June, 1903, was over 760 feet deep. It was generally understood that its section tallied with the old one fairly closely so far as the latter went down. The "5-foot bed of clay" of the old well showed only 3 feet in the new. From approximately 570 feet in the new, gravel was abundant to 760. Below, a hard bed of clay had been encountered, light colored above, but growing much darker below.

Pushee well.—One mile south of Hammond; west of the railroad; depth, 380 feet; 340 feet of 1½-inch pipe, 40 feet of 1¼-inch pipe; no screen; flow recorded by Mr. Pacheco March, 1901, 14½ gallons per minute; April, 1901, 15½ gallons; by G. D. Harris, June 23, 1903, 11 gallons per minute; temperature, 70.6° F.

Robinson well.—Northwest quarter of the town (see analysis, p. 75); depth, 356 feet; size of pipe 2 inches; flow not ascertained because it is piped to various places quite inaccessible.

Roger's (Ben) well.—West of Hammond, 7/8 mile; depth, 284 feet; 2-inch pipe reduced to 1 inch; flow, 17 gallons per minute; temperature, 70.5° F.; cost, $142.

Section of Rogers's well, Hammond, Tangipahoa Parish.

Clay.
Quicksand to 75 feet.
Clay.
Sand, last 50 feet.
Lower end of screen (10 feet) stuck in clay bed.

Erastus Rogers's well.—Depth, 225 feet; pipe, 1 1/4 inches; flow 5 feet from ground, 2 1/2 gallons per minute; temperature, 70°; strainer (screen), 8 feet.

J. T. Smith's well.—One mile east of Hammond; depth, 235 feet; temperature, 69° F.; pipe 1 1/2 inches; flow, 6.5 feet above ground, 7 1/2 gallons per minute; age, one year; cost, $108.

W. B. Smith's well.—One-half mile southeast of Hammond; depth said by some to be 260, by others, 305, feet; pipe, 2 inches reduced to 1 1/4; temperature, 70.5°; flow, 11 1/2 gallons per minute; age, eight years.

Tigner well.—Two miles southeast of Hammond; flow, 20 gallons per minute; pipe, 2 inches; temperature, 70° F.

W. J. Wilmot's well.—Depth, about 370 feet; pipe, 2 inches reduced to 1 inch; flow, said to be 40 gallons per minute; pressure, 2 feet above the ground, 7.7 pounds per square inch; flows readily 14 feet above ground, with small leaks in pipe; would doubtless flow 20 feet above ground.

H. Walsh's well.—One and one-half miles south-southeast of Hammond, in section 31; depth, 298 feet; pipe, 1 1/2 inches reduced to 1 inch; flows through 30 feet horizontal pipe, with stopcock, 5 1/2 gallons per minute; temperature, 70.75° F.; age, five years.

Way well.—One and one-half miles south-southwest of Hammond; depth, 140 feet; flow, 3 gallons per minute; temperature, 69° F.

Summary of wells about Hammond.—Water may be had by pumping, from wells ranging in depth from 30 to 100 feet: a

sand, or quick-sand, furnishes a slight flow generally at 140 to 150 feet, flow or not depending on topography; temperature, 69° F.; after passing more clay, to depths ranging from 230 to 380 feet, coarser sand or gravel is encountered, furnishing an artesian flow above the ground of from 10 to 20 feet, according to topography; temperature, 69° to 72° F.

The well of the Mineral Water Company, with 3-inch pipe, and a depth of about 460 feet, with a flow of 65 gallons per minute, as well as the log of the oil well, shows conclusively that better and larger wells may be expected in this vicinity. The Morrison and Durkee wells, some distance apart, in the central portion of the town, have shown no change whatever in flow for the past two years. Since they are of the normal size and depth it is evident that the available supply is as yet far greater than the demand.

In a radius of two miles of Hammond there are already about 50 flowing wells, yielding about 1,000 gallons of water per minute, or half a billion gallons annually, nearly all of which is wasted.

Decrease in the flow of certain wells in this neighborhood is due solely to increased obstruction in the lower end of the pipe.

The cost of these wells is not far from 50 cents a foot, labor, casing, etc., being furnished by the driller. The usual size pipe is 2 inches in diameter; in case smaller pipe is used the cost of the well is somewhat less. See notes on J. T. Smith's well, above.

Age of the wells examined, from two months to ten years. When properly screened, or put down into coarse gravel, these wells seems to flow as freely now as when first put down.

Local well drillers: Bacon and Gamble, Edwin Way, John Blumquist.

PONCHATOULA

The elevation of the railroad station at Ponchatoula is 29 feet above tide.

Alber well.—Two hundred feet from the town well; depth, 413 feet; pipe, 2 inches; flow, 25 gallons per minute; head about 30 feet above the surface of the ground. Bacon and Gamble, drillers.

G. H. Biegel's well.—At Pelican Hotel; depth, 232 feet; flow, 4¾ gallons per minute, 1901; 2¾ gallons per minute, 1903; temperature, 71° in 1901; 69.5° in 1903; pipe, 1½ inches; height of flow about 31 feet above tide.

Mrs. Bishop's well.—Old, deserted place, 3 miles north of Ponchatoula, 2 miles south of Hammond; depth 170 feet; pipe, 1½ inches; temperature, 69.5° F.; flow, 10 gallons per minute; age, about nine years.

The section of this well, according to John Blumquist, who drilled it, is as follows:

Section of Bishop well, Ponchatoula

	Thickness in feet.	Depth in feet.
Clay	50	50
Sand, with some water	20	70
Blue clay	94	164
Coarse sand	6	170

C. A. McKinney's well—About ½ mile southwest of Ponchatoula; depth, 199¾ feet; flow said to be variable, caving in evidently taking place below; on June 24, 1903, 12 gallons per minute; pipe 1½ inches; age, four years.

Moon well.—Same general vicinity as preceding; depth, 200 feet; pipe 1¼ inches; flow, 12 gallons per minute; age, seven years. Near by this is the Fisher well with a flow of 10 gallons per minute.

Railroad well.—At Chester 100 feet north of fiftieth milepost from New Orleans, west of track and five feet below the level of rails; flow, 3¾ gallons per minute; pipe, 1¼ inches; temperature, 70° F.

Town well.—In public square; flow, 1901, 2½ gallons; in 1903, 2⅓ gallons per minute; temperature, 71°, 1901; 70°, 1903. See table of analyses for further information regarding this and the Biegel well.

Sawmill well.—Depth, 332 feet; flow, 5 gallons per minute.

Section of sawmill well, Pontchatotula

[Section given by Bacon and Gamble]

	Thickness in feet.	Depth in feet.
Yellow and gray blue clay	75	75
Gray sand and gravel	15	90
Blue clay, about	35	125
Fine blue sand	105	230
Coarse white sand	30	260
Fine blue sand, with thin beds of clay	40	300
Sand a little coarser, weak flow of water	32	332

ORLEANS PARISH

The fact that there are two well-defined water-bearing strata [a] under New Orleans has already been mentioned. A number of additional facts can now be presented.

The old Canal street well of 1854, so often referred to in geological literature, both on account of its great depth, as borings then went, and, more especially on account of the careful record kept by Mr. Blanchard of the beds passed through, including many fossils, still remains the type section for this general region of the country down to a depth of 630 feet. No recent boring has been recorded with the interest and painstaking care that was displayed in this well. This is most seriously to be regretted, as the number of wells sunk has been very large, and their records, if carefully kept, would furnish material for an interesting chapter in the geological history of the southern Mississippi Valley. The records of the deeper wells, ranging from 1,200 to 1,400 feet, have been wanting altogether. The record of the Fabacher well, given below, will therefore be of unusual interest to those who are interested in the geology of New Orleans, either from a purely economic or scientific point of view. Fortunate, too, from a geological standpoint, is the collapsing of the screen at the base of the casing in the Young Men's Gymnasium well, at a depth of about 1,300 feet allowing the sand and fine shells to enter the pipe and be brought to the surface by the force of the flowing water.

[a] Rept. Geol. Survey Louisiana for 1902, p. 221.

DEEP SALT-WATER WELLS.

Young Men's Gymnasium Club Well.—Depth supposed to be 1,356 feet, although some claim that 1,250 is nearer the truth; natural flow, 40 gallons per minute; forced, 125 gallons; gas escapes at the rate of 830 cubic feet in twenty-four hours; specific gravity, 1.016.

Analysis of water of well at Young Men's Gymnasium Club

[Ordway and Kirchoff, analysis]

	Parts in 100,000.	Grains per gallon.
Chloride sodium	2,115.9	[a]2.82
Chloride calcium	138.2	81.2
Chloride magnesium	75.7	44.9
Chloride ammonia	1.3	.8
Chloride potash	Trace.	Trace.
Carbonate calcium	86.8	40 8
Oxides of Fe and Al	4.7	2.8
Phosphate	Trace.	Trace.

[a] Ounces.

Fabacher's well.—At Fabacher's "Casino," corner Nashville avenue and St. Charles street; depth, 1229 feet; pipe, 4 inches; flow, 1 foot above ground, 55 gallons per minute; flow, reduced to 2 inches and raised 10 feet above the ground, 6 gallons per minute; flow stops at 12 feet above ground; temperature, 81.5°F.

Section of Fabacher's well, New Orleans

[Furnished by Mr. Blakemore]

Character of material.	Thickness in feet.	Depth in feet.
Blue clay	37	37
White sand with shells	20	57
Yellowish-white clay	5	62
Grayish sand	105	167
Blue clay	20	187
Reddish sand	20	207
Gray sand	80	287
Blue clay, with pockets of shells	280	567
Gray sand	2	569
Blue clay	40	609
Hard white clay	19	628
Hard blue clay	30	658
Blue water sand (fresh water)	225	883
Blue tenacious clay	150	1,033
White sand (resembling white sugar)	40	1,073
Blue clay	85	1,158
Fine shells	6	1,164
Gray water sand	65	1,229

A forthcoming report will deal with the fossil remains saved from this well by Mr. Fabacher, and similar ones preserved by Mr. John Kracke, from the gymnasium well. They appear to be of Pleistocene or Quaternary age.

THE COMMON "YELLOW-WATER" WELLS.

These include the 600 to 900 foot wells bored at frequent intervals over the city. One of the earliest wells of this class sunk in New Orleans was in the neutral grounds on Canal street, between Carondalet and Baronne streets, in the year 1854. A colored section of this well, as originally kept by A. G. Blanchard, C. E., of New Orleans, appears in the report of the board of health of Louisiana for 1890-91.[a] From this it will be observed that the strata penetrated to a depth of 630 feet consist of light yellowish and bluish sands and clays with some light greenish layers and occasional shell sands.[b]

One of the most recent wells of this class is that at the Marine

[a] Biennial Rept. Board of Health to the general assembly of the State of Louisiana for 1890-91, plate opposite p. 148. Baton Rouge, 1892.

[b] Rept. Geol. Survey Louisiana for 1902, p. 221.

Hospital, Audubon Park. This is 765 feet deep. The first 600 feet are reported as sand, silt, and clay beds; a bed of yellow sand, perhaps 40 feet thick, was encountered some distance below, and continued to 705 feet. From there on for 60 feet the material consists of white sand. The water rises to within about 3 feet of the surface at present. This 6-inch well is capable of furnishing 300 gallons per minute. The water is classed as excellent for washing purposes, requiring but half as much soap as the river water. It is also excellent for boiler purposes, but is impotable.

The flow from this shallower class of wells has always been weak, and the large number of such wells has still further weakened the flow. There is a tendency now, when more water is required to seek the lower level. This water is excellent for bathing purposes, containing, as the above analysis shows, a large amount of common salt.

The great range in depth here given really includes two or more water-bearing horizons, though at various localities but one may be represented.

THE 400-FOOT SANDS

In the old well on the neutral grounds, just referred to, a sand bed was passed through from 335 to 480 feet below the surface that furnished artesian water at the rate of 350 gallons an hour.

SHALLOW WELLS

Very close by Mr. Fabacher's deep well, above described is a well but 180 feet in depth, fitted with a 3-inch casing, that flows 12 gallons per minute 1 foot above the surface of the ground. It is brackish. Temperature, 70° F.

Small driven wells in the city limits, at varying shallow depths, reach sandy, coarse material that bears water, evidently closely connected with the river.

BONNABEL WELL

One of the most interesting wells that has ever been put down in the vicinity of New Orleans is that on the shore of Lake Pontchartrain, about 1 mile west of West End. An attempt was here made to start a summer resort under the name of Lake City, and this well was sunk for a supply of fresh water. According to

Mr. Bonnabel, the well is 1,200 feet deep, but a letter from the driller indicates that it is not over 900 feet deep. It now flows from a 2¾ inch pipe, standing about 8 feet above tide, 12 gallons per minute, with a temperature of 79° (measured July 5, 1903).

Mr. Bonnabel makes the following remarks regarding the well section :

Five-inch casing to 600 feet, hitting rock ; 3-inch casing to 700 feet ; then 1½-inch casing to 1.200 feet. Compact, ferruginous conglomerate, 60 feet thick, was passed through about 700 feet down ; then a black, hard clay was encountered, giving way to bluish sand ; water in pale blue clay.

The analysis of the water by Mr. Joseph Albrecht, as given in a handbook regarding "Lake City," is as follows :

Analysis of water from Bonnabel well

	Grains per gallon.
Sodium chloride	27.74
Sodium carbonate	34.39
Potassium carbonate	4.49
Silica carbonate	1.69
Organic matter free of nitrogen	0.46
Carbonic acid combined as bicarbonates	13.33
Total	82.10

The features of the section outlined by Mr. Bonnabel are in some ways remarkable, and if it were certain that there is no error in the matter there might be grounds for supposing that there had been some orogenic movement in this region that brought up rocks belonging to a horizon beneath the Pleistocene to an elevation of but 600 feet below tide level. It is probable that the water comes from the same stratum that is found at a depth of 500 to 600 feet about Covington and Abita Springs, and that it is the same as the 600 to 900 foot sand beds penetrated and so largely drawn from throughout the city of New Orleans. The fact the water may be potable at Covington, barely so at Lake City, and quite impotable in New Orleans, is readily explained by the very slight slope of the water-bearing stratum, and hence the very slow movement of the underground waters. A slope of perhaps 150 feet in 35 or 36 miles can scarcely give an appreciable daily motion through sand that is generally very fine. When we consider also the rapid formation of this costal region of Louisiana, and the great amount of organic matter that was

brought Gulfward then as well as now and deposited along in the sand and clay beds of Pliocene times, it is no wonder that the slowly moving waters should become strongly impregnated with various salts and so-called impurities as they pass Gulfward (see fig. 4).

Since such is the condition of affairs in and about New Orleans there seems to be no valid reason for supposing that the city will ever be supplied with potable artesian water derived from local wells.

ST. JOHN THE BAPTIST PARISH

RUDDOCK

Mr. John Blumquist, Hammond, says that the well at this place opposite the railroad station is 338 feet deep. It flows strongly, but the water stains everything red, even glass.

EAST BATON ROUGE PARISH

BATON ROUGE AND VICINITY

Waterworks, two wells.—Old well put down in 1892; depth, 758 feet; water rises to within 6 feet of surface, i. e., approximately 30 feet above tide; capacity given as 500,000 gallons daily.

Analysis of water of waterworks well at Baton Rouge

[B. B. Ross, analyst]

	Grains per gallon.
Total solid matter	14.3175
Mineral matter	12.1597
Organic and volatile matter	2.1578
Silica	1.3413
Potash	.2251
Soda	5 9929
Lime	50c9
Magnesia	.2939
Oxides of Fe and Al	.5056
Phosphoric acid	.03196
Sulphuric acid	1.8819
Chlorine	.4655
Oxygen oxidizing organic matter	.04228
Nitrogen, albuminoid ammonia	.cc676
Nitrogen as free ammonia	.00519
Nitrogen as nitrates	.00192

Sulphuric acid and chlorine combined as—

Potassium sulphate	.4171
Sodium sulphate	3.0022
Sodium chloride	.7494

This well has an 8-inch pipe for 386 feet; 6-inch pipe for 304 feet; 4¼-inch pipe for 68 feet. New well starts with 10-inch pipe, and is 6 inches the rest of the way down; depth, 800 feet; flow at surface about 35 feet above tide.

The two wells are said to have a capacity of 1,000,000 gallons a day. Pumped with compressed air.

Istrouma Hotel well.—Depth, according to the Blakemore Well Company, of New Orleans, 770 feet; water stands 18 feet below the surface of the ground. It is of the same quality as the water obtained at the water works, and pumps with a suction pump at the surface about 80 gallons per minute.

Well 4 miles east of Baton Rouge.—Pipe 4-inch, flow from 2-inch hole 4½ feet above ground, 5 gallons per minute; from 2-inch hole 1½ feet above ground, 30 gallons per minute; temperature 71° F. Pressure head about 50 feet above tide.

BAKER

Well at old mill, one-fourth mile south of station.—Depth, 850 feet; 2-inch pipe; has flowed freely 16 feet above present faucet. It now furnishes large quantities of water.

Elevation of pressure head, about 100 feet above tide. (Elevation of Baker station given by Gannett as 82 feet above tide.)

Driven wells, 150 feet deep, furnish fair water. Bored wells, 25 to 40 feet deep, yield very impure water.

ZACHARY

Wells here, some as deep as 200 feet have to be pumped. Most of the water used is from shallow bored wells.

WEST FELICIANA PARISH

BAYOU SARA

Well just southeast of railroad station, 240 feet deep; passed through gravel at 100 feet. It is pumped. Darton gives the following data from one well at this place: Depth, 736 feet; pipe 4 inch; yield, 347 gallons; height of water [above mouth of well ?] +2 feet; temperature 63°. For another he gives simply depth 450 feet and "height" + 1 foot.

ARTESIAN AND DEEP WELLS IN LOUISIANA WEST OF THE MISSISSIPPI

LA FOURCHE PARISH

THIBODAUX

Ice factory well.—Depth, 225 feet; passes through moderately fine bluish sand all the way down; water impotable on account of various salts; stands 13 feet below the surface of the ground; used for condensing.

ASSUMPTION PARISH

NAPOLEONVILLE

City waterworks.—Two wells, an 8-inch, 190 feet deep; a 6-inch, 210 feet deep. Both said to furnish 25,000 gallons per hour; the smaller, and deeper, with 9-foot strainer, furnishes more water than the larger, with 20-foot strainer.

Several such wells around the town furnish a similar water, i. e., very ferruginous, staining bath tubs and connections an orange yellow.

ST. JAMES PARISH

St. James well.—Mr. Weasel, contractor for well drilling on the Texas and Pacific Railroad, says that at St. James he found good water at a depth of 285 feet, passing through a bed of shells (probably *Rangia* shells).

Convent well.—Mr. C. Oley, of the Blakemore Well Drilling Company states that here he put a well down to the depth of 190 feet and procured good water. It rises and falls with the Mississippi.

ST. MARY PARISH

MORGAN CITY

Well penetrated a very coarse gravel bed at a depth of 500 feet.

GLENCOE.

Clendenin[a] gives a section of an artesian well at this place furnished by Doctor Simmons. It shows coarse sand and water at a depth of 615 feet.

[a] Part III, Geol. and Agric. State Exp. Sta., 1896, p. 243

Section of well at Glencoe, St. Mary Parish

	Thickness in feet.	Depth in feet.
Soil	1	1
Yellow clay	11	12
Quicksand	12	24
Blue clay	100	124
Shale	Undeter-	......
Tough, gray clay	mined.	......
Coarse sand and gravel and water at	....	615

IBERIA PARISH

JEANERETTE AND VICINITY

Moresi's barnyard well.[a] —Depth, 140 feet; pipe, 1¼-inch; flow, February 16, 1901, 7½ gallons per minute; temperature, 70°. See table of analyses given on page 75.

Elevation of station, 18 feet above tide; well, 13.2 feet below station; hence flow is about 5 feet above tide.

Moresi's foundry well.—Depth, 700 feet. See table of analyses given on page 78. Section given as follows:

Section of Moresi's foundry well at Jeanerette, Iberia Parish

	Thickness in feet.	Depth in feet.
Clay	40	40
Sand and gravel	160	200
Blue and gray clay, shells and red water	460	660
Gravel	40	700

Elevation, 5.5 feet below railroad station; water stands within 5 or 6 feet of the surface; hence water is about 8 feet above tide.

Ice factory well.—Pipe, 8-inch. Clendenin gives this well section as follows:

[a] Rept. Geol. Survey Louisiana for 1902, p. 232.

Section of well at Ice factory, Jeanerette

	Thickness in feet.	Depth in feet.
Red clay	15	15
Mottled clay and sand	80	95
Organic bed	10	105
Sand and gravel	70	175
Yellow clay	175	350

Flow from base of cap, 7.69 feet below railroad station or about 10.5 feet above tide.

Old Moresi plantation.—One mile southeast of Jeanerette; depth, 180 feet; flows freely about 8 feet above tide; stains pipes and connections bright reddish yellow.

S. B. Roane's well.—Three miles south of Jeanerette; depth, 420 feet; pipe, 10-inch; water flows over the top of pipes perhaps 10 feet above tide when wells are not pumped for a time; water seems good for general family use; potable; wells pumped for rice irrigation. This is known as the Kilgore plantation. The section is as follows:

Section of Roane's well at Kilgore plantation, near Jeanerette, Iberia Parish

	Thickness in feet.	Depth in feet.
Clay	80	80
Gravel	6	86
Clay, full of shells	150	236
Gravel and sand	184	420

NEW IBERIA

Ice works wells.—Depth, about 230 feet; quality and quantity not as desired for general use; pipes soon cake and clog up.

John Emms's well.—Depth, about 260 feet; extremely ferruginous; not potable; rises 5 feet above the bayou at mid-stage.

Oil well.—North of New Iberia; depth, said to be about 500 feet, with pockets of oil, and one "rock" 2 feet thick; good water also reported at a depth of about 400 feet.

The quality of the water at the Roane well, mentioned above, is such as to seem to bear out ex-Mayor Moresi's statement that good water is to be found only at the usual depths some distance back from the bayou. It is probable that the problem of furnishing New Iberia with good water will be solved by pumping it from a station a few miles to the west. Mr. Caldwell, the machinist, vouches for the statement that good water was found in the "Oil" well.

ST. MARTIN PARISH

ST. MARTINVILLE AND VICINITY

Oil well —About 1½ miles northwest of St Martinville.

Section of oil well near St. Martinville St. Martin Parish

[According to Mr. William Kennedy]

	Thickness in feet.	Depth in feet.
Clay and soil	40	40
Fine sand	60	100
Blue clay	40	140
Water-bearing sand and gravel	150	290
Tenacious clay and gravel	25	315
Water-bearing sand and gravel	120	435
Tenacious clay, with gravel	200	635
Coarse sand	200	835
Tenacious clay and gravel	150	985
Coarse sand and gravel	150	1,135

It will be observed that two beds of water-bearing sand and gravel are mentioned. Doubtless other sand and gravel beds, like the lowest penetrated, would furnish an ample supply of water, though very likely to be salty.

The Southern Pacific Railroad station is marked 25 feet above tide ; a spirit-level line to the well shows that the floor of the derrick is 16.3 feet above tide. For diagram of this well see Pl. II.

In an irrigation well close by the water surface stood at a height of 11.6 feet above tide January 13, 1903.

Labbe's well.—Four miles south of St. Martinville ; spirit-level line from St. Martinville showed surface of water to be 11.13 feet above tide ; surface of the land 17.3 feet above tide January 14, 1903.

BREAUX BRIDGE

Gilbeaux place.—Three-fourths mile west of station, on Gilbeaux plantation; elevation of railroad station 27.5 feet above tide; well pipe 12 feet above tide; water said to have flowed over the top of this pipe when well was first put down.

LAFAYETTE PARISH

LAFAYETTE AND VICINITY

Waterworks wells.—We have here an instance of lack of care in leaving the orifice of the wells accessible, so that the wells may at any time be cleaned, or rather flushed, when clogged with sand. Three wells have been put down here in succession, because, after a few years, they became clogged up. The depth of the new and consequently best well was given as 226 feet. Its casing is 6 inches; screen, 35.5 feet long. This well supplies LaFayette, besides 220,000 gallons to the Southern Pacific Railroad daily; height of surface of ground, reckoning Lafayette station as 40 feet, about 34.6 feet; water said to be between 20 to 25 feet below, hence about 10 or 15 feet above tide; when cleaned occasionally it is as good as when first put down; screen in very coarse gravel; C. H. Melchert, engineer in charge.

Lafayette Compress and Storage Company's well.—Depth, 125 feet; water surface about 25 feet below surface of the ground, i. e., about 10 feet above tide.

ST. LANDRY PARISH

OPELOUSAS

Waterworks well.—Depth, 184 feet; pipe, 10 inches; screen, 64 feet; has been pumped to the extent of 300 gallons per minute, guaranteed 600; elevation of water in well, 22.28 feet above tide, i. e., considering the station as 67.5 feet, as given by the Southern Pacific Railroad.

Section of waterworks well at Opelousas, St. Landry Parish

	Thickness in feet.	Depth in feet.
Clay	83	83
Fine sand	37	120
Gravel to bottom of well	64	184

Oil Mill Well.—Depth, 208 feet; pipe, 8 inches, with 40 feet of screen.

WASHINGTON

Washington well.—The following section was given for the well at Washington:

Section of well at Washington, St. Landry Parish

	Thickness in feet.	Depth in feet.
Quicksand	18	18
Sand	52	70
Gravel	124	194

Water said to rise to within 11 feet of surface of ground, or about 30 feet above tide.

WEST BATON ROUGE PARISH

BATON ROUGE JUNCTION

Mr. Weasel says he found good water here at 160 feet.

LOBDELL

The same authority just quoted says that good water is found here at a depth of 150 feet. The surface of the water is 21 feet below the general level of the ground.

POINTE COUPEE PARISH

NEW ROADS

Mr. Weasel reports poor water at 120 feet.

BATCHELOR

The same condition exists here as at New Roads.

AVOYELLES PARISH

BUNKIE

Railroad wells.—One 90, the other 142 feet deep; the water from both impotable. Water stands in both about 13 feet below station.

W. D. Haas's well.—One 4-inch well, 180 feet deep, furnishes enough water to run four large boilers in Haas's cotton compress works; water stands about 10 feet below surface of ground or about 11.5 feet below the station.

Gannett gives Bunkie an elevation of 66 feet. Hence water stands in these wells about 52 or 54 feet above tide.

MARKSVILLE

Court-house well.—This well is reported to have a depth of 800 feet, encountering salt water. At a depth of 230 feet a 5-foot stratum of lignite was penetrated. Mouth of well 0 3 foot above railroad station, hence approximately 82 feet above tide.

VERMILION PARISH

ABBEVILLE AND VICINITY

Court-house well.—Well about 16.6 feet above tide with section as follows:

Section of well at court-house, Abbeville, Vermilion Parish

	Thickness in feet.	Depth in feet.
Clay	15	15
Fine sand	65	80
Clay	2	82
Hard layers of clay alternating with sand	57	139
Coarse white sand with white pebbles	21	160
Reddish clay and "rock"	60	220

The upper bed here alone furnishes water. Exact height of water could not be told; certainly it lacks several feet of overflowing.

Well 9 miles west of Abbeville.—On Mr. John Waltham's place W. ½ SE. ¼ sec. 32, 12 S., R. 3 E., are several wells. The land is here 10 feet above tide and the general well section, according to Mr. Moresi, is about as follows:

Section of well on Waltham's place, 9 miles west of Abbeville, Vermilion Parish

	Thickness in feet.	Depth in feet.
Clay	30	30
Gray sand	10	40
Clay	5	45
White sharp sand and gravel	30+	75+

Even at this low level the water does not overflow.

SHELL BEACH

Wells that have a feeble flow above the surface of the ground were heard of at this place, but were not visited.

GUEYDAN

Wilkinson's well 3 miles southwest of Gueydan.—Depth, 190 feet; pipe, 8-inch; flow, 8+gallons per minute; temperature, 73°. Elevation of flow, 6.9 feet above tide, determined by spirit-level line from Gueydan; bench mark on station; according to Southern Pacific Railroad, 9.07 feet above tide.

Donnelly place, 6 or 7 miles east of Gueydan.—Two 8-inch and two 6-inch wells. Water said to rise 8 inches above the surface.

ACADIA PARISH

RAYNE AND VICINITY

Chapuis's well.—Depth, 210 feet, with 10-foot strainer; water stands 16 feet below surface. Elevation of station, according to Southern Pacific Railroad, 37.5 feet above tide, well about 2 feet below; hence, water in well about 19.5 feet above tide.

Hippolite Richard's well.—This is 3 miles east-northeast of Rayne. Depth, 200 feet; water stands within 17.5 feet of surface. Elevation of surface of water in well about 20 feet above tide, based on spirit-level line run from Rayne to mouth of well.

CROWLEY AND VICINITY

Railroad well.—Depth, 173 feet. Water usually rises to within 5 or 6 feet of surface. Elevation of water, about 19 feet above tide.

Ice factory well.—Depth, 600 feet; water unsatisfactory; pipe withdrawn to the usual depth, 170–180 feet.

Long Point, 15 miles northeast of Crowley.—One 8 inch and three 6 inch wells. Water at 180 feet; rises to within 26 feet of the surface.

Three miles east of Crowley.—Two wells pass through logs at depth of 168 and 202 feet. In the first, beneath the 168-foot log, 7 feet of water-bearing sand was encountered, water rising to within 7 feet of surface.

Sol Wright's well.—About 3 miles southwest of Crowley, or in center of sec. 19, T. 10 S., R. 1 E.; depth, 293 feet; surface

of ground, 19.37 feet above tide; of water, 9.37 feet above tide January 29, 1903. Strainer, 70 feet long.

L. J. Bowen's well.—Middle of NE. ¼ sec. 19; depth, 196.6 feet; top of pipe, 21.39 feet above tide; of water, 9.49 feet above tide.

MIDLAND

Water stands in this well, February 5, 1903, 10.5 feet below station; hence 7.5 feet above tide.

ORIZA AND VICINITY

John Wendling's well, 1 mile southwest of Oriza.—Pipe, 6-inch; flow, 1.2 feet above surface; 20 gallons per minute. Elevation of Oriza (Southern Pacific Railroad), 24 feet above tide. By spirit-level line, top well is 11.4 feet above tide.

D. J. Scanlin's well, 2 miles southwest of Oriza.—Elevation of surface of water, 12.2 feet above tide; line from Oriza.

F. Scanlin's well, 2 miles south-southwest of Oriza.—Elevation of surface of water, 12 feet above tide; leveled from Oriza.

CALCASIEU PARISH

It is in the eastern half of this parish that perhaps two-thirds of all the large irrigation wells of southwestern Louisiana are located. Not that this particular area is better adapted to the growing of rice than many other sections of southern Louisiana, but by a glance at any map of this part of the State it will be seen that east Calcasieu has comparatively few large rivers, creeks, or bayous from which water may be had for irrigation purposes. The result is that here are found the most advanced methods of sinking wells and lifting the water from them.

It is entirely out of the question to refer to even a tenth part of the wells now in operation in this section; of late years their number has gone up into the hundreds, and will soon reach a thousand or more. A few statistics regarding some of these wells will show the general characters of all of them. Welsh may be taken as the central point of interest in deep well activity.

WELSH AND VICINITY

E. L. Bower's well.—About one-half mile northeast of Welsh, center of sec. 30, called in the last report of the Geological Survey of Louisiana (1902) "E. L. Brown's well;" depth, 130 feet;

pipe, 8 inches; strainer, 38 feet; surface of water above tide February 26, 1901, 16.68 feet; March 21, 1903, 13.92; July 13, 1.18 feet. The section shows clay to 65 feet and sand, growing coarser below, to 130 feet.

Mr. Bower has recently put down another well 92 feet north of this well; it has a 10-inch casing, is 175 feet deep, and has a 56-foot strainer. From top of pipe to water surface, March 21, 1903, 6.73 feet, the water stood 13.26 above tide; July 13, 1903, 0.5 foot above tide.

Cooper's well, ½ mile east of Welsh.—The section shows clay to 90 feet, coarse sand, clay, sand, and finally blue sand at a depth of 140–145 feet.

Field's well, ¾ mile east of station.—The section shows clay to 90 feet; sand, clay, coarse below, to 164 feet.

Welsh planing mill well.—Pipe, 3 inches; top of pipe, 20.33 feet; surface of water, March 19, 13.86 feet; March 21, 13 93 feet above tide.

Section of well at Welsh planing mill, Welsh, Calcasieu Parish

	Thickness in feet.	Depth in feet.
Clay	12	12
Sand	4	16
Clay	182	198
Coarse, light sand	40	238

S. R. May's well, ¼ mile north of station.—Top of flume 20.3 feet above tide; of water, March 19, 1903, 14.3 feet; March 21, 15.16 feet; July 12, 1903, 0.8 foot above tide; July 13, after pump had been working 1 hour, but had stopped 5 minutes before the measurement was taken, 1.7 foot above tide; same conditions except pump had been stopped for about 20 minutes, 1.1 foot above tide; lowest level in 1902 said to be —8 feet; depth, 190 feet; pipe, 8 inches; temperature of water, 71.5° F.; supplies 1,200 gallons per minute when pumped by a 20-horsepower Erie engine.

Abbot's well, 2 miles southeast of Welsh.—Elevation of water surface, February 25, 1901, 16.42 feet above tide; that is, 7.08 feet below the railroad station.

Herald's well, perhaps 1½ miles east-southeast of the station.—Elevation of water, February 26, 1901, 16.6 feet above tide, or 6 9 feet below the railroad station.

Well 9 miles north-northwest of Welsh.—The section shows clay to 192 feet and sand to 235 feet.

LAKE ARTHUR

Wells at mills reported as flowing 5 feet above tide.

R. E. Camp's well, 1½ miles northwest of Lake Arthur.—Southeast ¼ sec. 8, 11 S, 3 W.; depth, 215.7 feet, water-bearing sand 40 feet thick; elevation of top of pipe as determined by a spirit-level line from the lake, 17.5 feet above tide; elevation of water surface, 8 feet above tide.

JENNINGS AND VICINITY

Anderson's wells, about 1 mile west south-west of Jennings.—Three 10-inch wells, connected to a 14-inch main and pumped with a 50 horsepower engine. Depth, approximately, 300 feet; wells about 20 feet apart, furnishing, with engine running at perhaps half-rated power, 1,800 gallons per minute.

These wells are furnishing now (1903) about half as much water as they did last year owing to clogging of the strainer with fine sand. The fireman at the plant says the 150-foot well, about 50 feet north of the three, is capable of furnishing nearly as much as these three are furnishing now. Though so various in depth when the deeper wells are pumped, the amount obtainable from the shallower one is materially diminished.

Carey's wells.—In this same vicinity are the three Carey wells, a general log of which is herewith given:

General section of three wells near Jennings, La.

	Thickness in feet.	Depth in feet.
Clay, with shells at about 50 feet, and with vegetable matter and a log below	115	115
Quicksand above, gravelly below	45	160
Bluish, sandy gravel	20	180
Sandy clay	50	230
Gravel	30	260

City waterworks well.—When measured, March 19, 1903, the water in this new well stood 18 feet below the mouth of the pipe or,

perhaps, 12 feet above tide. The capacity of the tank is 65,000 gallons. The engineer informed us that the well seemed to lower none while the tank was being filled, the operation lasting about three hours.

Well 3 miles east-southeast of Jennings.—This well was being sunk on February 24, 1900, by the Brechner outfit. The beds penetrated showed reddish, yellow, and gray mottled clay for 30 feet, becoming less tenacious, with fossil fragments, *Rangia*, *Helix*, *Balanus*, etc., until a depth of 90 feet was reached, when blue sand, with thickness undetermined, was struck.

KINDER AND VICINITY

McRill's well, 1 mile north of Kinder.—Depth, 150 feet; elevation of water surface as determined by leveling, from Kinder Station, March 8, 1902, 27.1 feet above tide, assuming that the station is 49.3 feet above tide.

Tillotson's well.—Depth, 138 feet; depth of water from top of pipe, 21 feet, 10 inches; temperature, 68° F.; elevation of water surface March 7, 1902, 25.4 feet above tide.

CHINA

McBirney's wells.—A number of wells in this vicinity, ranging in depth from 140 to 175 feet and in size from 6 inches to 8 inches, in which water rises to within 14 to 23 feet of surface, depending on local topography.

OBERLIN

Mr. Dennis Moore says that the railroad tank well is 190 feet in depth, and that water rises to within 10 feet of the surface, or about 60 feet above tide.

In general the water level would probably be somewhat lower than this. No hopes can be entertained of obtaining a flowing well at this comparatively shallow depth.

LAKE CHARLES

Well 1 mile north of lake.—The Bradley and Ramsay Lumber Company's well, about 500 feet deep, has the greatest flow of any well measured in the State, 210 gallons per minute; pipe, 6 inches. See analysis given below. (See Pl. VI, *A*, for view of well.) Elevation, 10.5 feet above tide. Based on tide gage reading at Lake Charles, by G. D. Harris.

Reiser's machine-shop well.—The following is a section of the well:

Section at well at Reiser's machine shop, near Lake Charles

	Thickness in feet.	Depth in feet.
Sand	96	96
Red sand with pebbles	6	102
Gray sand and clay alternating	98	200

Water with iron taste. See analysis given below. Elevation of well about 13 feet; known to flow to 17 feet and said to have flowed to 27 feet above tide.

Judge Miller's Well.—Pressure of 5.25 pounds per square inch; flows 12 gallons per minute. Elevation of present flow, 12.72 feet above tide; would flow at 24.79 feet above tide.

WEST LAKE

Perkins and Miller Lumber Company's Well.—Pipe, 4 inches; elevation of flow, 10 feet above tide, and would doubtless flow to 16 feet or more above tide.

Well 3 miles northwest of lake.—Pipe, 8 inches. Following is a partial section of this well:

Partial section of well at West Lake, Calcasieu Parish

	Feet.
Hard clay between	250–350
Shells	300
Gravel	360

This is a very strong flowing well.

RAPIDES PARISH

BLOWING WELLS

It would doubtless be an unpardonable omission, if in enumerating the various classes of wells in southern Louisiana, with their depths, kinds of water, and other characteristics, no mention were made of the "blowing" wells of Rapides Parish, that have attracted much attention, at least locally.

Judge Blackman, of Alexandria, has frequently called attention to a certain well of this character, and has recently sent,

through Mr. Kennedy, of the Southern Pacific geological survey, a clipping from the Alexandria Town Talk, of September 19, 1903, relating to this subject.

Though Judge Blackman knows of two other wells having similar characteristics, the one best known is located on the farm of Mr. Frank Melder, Melder post-office, between Spring Creek and Calcasieu River, 2 miles east of the river, and 3 miles east of Strothers ~~Crossing, on the~~ Calcasieu.

It was in 1892 that Mr. Frank Melder started to bore a 12-inch well, but had to give it up after reaching a depth of 80 feet. The air would come rushing from the well, sometimes for a period of three or four days, and again at shorter periods. When the air was not rushing from the well, it would turn the other way and be sucked into the well with great force * * * The force of the air coming from the well would keep a man's hat suspended over it.

In boring the well a stratum of about 1 foot of pipe clay was penetrated, and for the remainder of the distance, over 75 feet, a bed of yellow sand was penetrated. While boring it was discovered that every foot deeper the well was sunk, the harder the air would blow from it. When the well was first completed, it would blow a day and then air would be sucked in for a day. No water ever appeared in the well at any period.

The subject of "blowing wells" has been discussed in Water-Supply and Irrigation Paper No. 29, by Mr. Barbour.[a] He attributes such phenomena, doubtless correctly, to changes of atmospheric pressure at the surface of the earth. Those interested in this subject will find, without doubt, that when the wells are "blowing," the barometer reading as recorded by the nearest weather station is low; when the wells are "sucking in," the barometer is rising.

It seems from the above statement regarding the section of the Melder well that its great capabilities as a "blowing" well are due to the absence of water between the grains of sand.

When such interstices are mainly filled with water, as is usually the case, the phenomenon of "blowing" is much less noticeable.

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[a] Barbour, E. H., Wells and windmills in Nebraska: Water-Sup. and Irr. Paper No. 29, U. S. Geol. Survey, 1899, pp. 78–82.

VARIATION IN FLOW AND PRESSURE HEAD SHOWN BY WELLS IN SOUTH LOUISIANA

WELLS EAST OF THE MISSISSIPPI

As a result of investigations already carried on, it is safe to say that the total amount of water obtained from deep and artesian wells in this part of the State north of Lake Pontchartrain does not exceed 3,000 gallons per minute. South of the lake, in the city of New Orleans, there are a number of 6-inch wells, but they are pumped so irregularly, both as to time and amount, and are so "connected up," that no safe estimate can be given as to their total yield. The water-bearing sands, ranging from 600 to 900 feet below the surface throughout the city, have been penetrated in so many places that the water rarely overflows from these wells. All admit that the head has been gradually lowered somewhat in proportion to the number of new wells put down. (For a record of the present stand of the waters in these wells, see pp. 40–43.)

There seems to have been a slight decline in the waters of the Mandeville region, if we may trust occasional measurements, yet by referring to the data presented under Mandeville (p. 132), it will be seen that some of the important wells are flowing now almost as much as two years ago. Some have become practially clogged up and of little or no value. The presumption is that, were new wells put down or were those now in existence occasionally flushed, the supply would be as great as ever from each well. Very few new wells have been put down in this vicinity during recent years.

About Covington the new wells seem to show the same head as those put down two or more years showed at that time. Here, too, there is a suspicion that the marked falling off of head in several of the wells is to be accounted for by the clogging of the pipes.

At Abita Springs it has been noticed that the flowing of the last new large well put down decreases to a marked extent the head in the wells close by, especially to the south and west. Some of the better wells, however, have shown an increase rather than a decrease, so that with care in properly spacing the wells and

judgment in using the water no one need expect to be obliged to resort to pumping for a long time to come.

At Hammond the better wells have shown no decrease of flow or pressure head for the last two years, even though their number has greatly increased during this interval.

When the extent of catchment area is taken into account, reaching, as it must, northward as far as Crystal Springs, Miss., and when the total amount of waters obtained from deep sources in this section of the State is considered, it is no wonder that there seems to be no general variation in flow or pressure head thus far recorded. Two moderate-sized rice plantations in southwest Louisiana would call for more water during the summer months than flows from all these wells combined. Until irrigation is practiced far more generally in this section of the country there will probably be no marked decline in the flow of the carefully constructed artesian and deep wells.

WELLS WEST OF THE MISSISSIPPI

The statement is often made that the wells along the Mississippi and in the alluvial or delta region to the west vary as to head according to the different stages of the river. In the lowest regions, close to the river channel, this probably means that when the river is very high, held far above the wells by the great levee system, some of the river water gradually seeps through the intervening soils and enters the wells. Many instances are on record of the pressure of the river water becoming so great as to cause a spring to burst forth from the ground several hundred yards from the river's border. When such waters are welled up to a height corresponding to that of the surface of the river, they cease to flow.

However, if it is assumed that the motion of most underground waters is but a few feet a day, or only a mile or two a year, it is evident that the underground transmission of water from the Mississippi eastward, westward, or Gulfward is not sufficiently rapid to be detected, and correlated with stages of the river except for a distance of a few hundred yards from the channel.

It is obvious, however, that there may be a transmission of pressure, affecting the flow of wells more promptly and at a greater distance than would the actual translation of the water

itself. Data touching upon this interesting question are in the delta region unfortunately lacking, and this for two reasons: (1) Since the water there obtained from wells is usually of poor quality, their number is not great, and (2) when they are put down they are nearly always on the bank of some navigable bayou where the villages and sugarhouses are to be found. The fluctuations of such wells may be due, as explained above, mainly to the lateral transmission of river or bayou water, and not to the simple transmission of pressure.

Wells farther west, some distance from the Mississippi and its distributaries, show, as will be seen below, no appreciable effect of transmission of either water or pressure from the Mississippi.

No observations continuing throughout the whole year have been made, so far as the writer is aware, of the height of water in the various deep wells in the southwest part of the State. As explained in the prefatory notice to this paper, the facts upon which this report is based were collected by the writer during the winter months, while engaged in general work of the State geological survey. However, several short series of observations have been made, covering intervals in three successive years. In 1901 Mr. Pacheco, of the State survey, was kept in the field nearly two months for the sole purpose of making such observations. The results of his observations, as published by the State survey, are as follows:

Variation of height of water in Hammill's well, 2½ miles south of station, Jennings, La.

1901.	Hour.	Feet.	Inches.	1901.	Hour.	Feet.	Inches.
Feb. 21	....	13	4.0	Apr. 29	A. M.	13	7.2
Apr. 20	....	13	9 5		P. M.	13	7.0
21	A. M	13	9 0	30	A. M.	13	7.16
	P. M.	13	8.5		P. M.	13	7.12
22	9 A. M	13	7 25	May 1	2 P. M.	13	7.0
	11 A. M.	13	7.0		4 P. M.	13	6.9
	12 M.	13	6.9		5 P. M.	13	6.8
	2 P. M.	13	6.87	5	....	13	7.75
	3 P. M.	13	6.75	6	A. M.	13	7.75
	5 P. M.	13	6.75		P. M.		
24	....	13	8.75	14	....	13	10.25
25	....	13	8.0	15	....	13	11.0
26	A. M.	13	8.33	16	....	13	11.75
	P. M.	13	8.25	17	....	14	0.125
27	10 A. M.	13	8.5	18	....	14	2.0
	11 A. M.	13	8.4	20	....	14	2.0
28	....	13	7.0	Water dropped below pump.			

Variation of height of water in Lawson's well, 1 mile east of station, Jennings, La.

1901.	Hour.	Feet.	Inches.	1901.	Hour.	Feet.	Inches.
Apr. 21	10 A. M.	6	5.75	May 2	10 A. M.	6	6.25
	6 P. M.	6	4.12	5	3 P. M.	6	7.25
22	8 A. M.	6	4.0		3.30 P. M.	6	7.0
	6 P. M.	6	3.9		6 P. M.	6	6.8
23	8-11 A. M.	6	4.0	6	....	6	6.83
24	P. M.	6	4.37	18	....	7	5.25
25	7 A. M.	6	4.2	19	....	7	3.5
26	A. M.	6	4.37	20	....	7	2.87
	P. M.	6	4.33	22	....	8	......
27	......	6	4.75	24	....	8	......
28	9 A. M.– 4 P. M.	6	5.33	1902.			
29	8 A. M.	6	5.8	Feb. 22	....	7	10.25
	2 P. M.	6	5.75	23	....	7	10.25
	6 P. M.	6	5.66	25	....	7	9.75
30	....	6	6.0	26	....	7	8.5
May 1	9 A. M.	6	6.12	27	....	7	8.25
	11 A. M.	6	6.12	Mar. 11	....	7	9.25
2	8 A. M.	6	6.12	13	....	7	9.125

Variation of height of water in Bower's well, Welsh, La.

1901.	Hour.	Feet.	Inches.	1901.	Hour.	Feet.	Inches.
Feb. 26	....	4	6.0	May 12	....	4	2.5
Mar. 21	....	4	3.0	13	....	4	2.75
Apr. 20	....	4	1.25	14	....	4	2 75
23	....	4	1.5	15	....	4	3.5
24	8 A. M.	4	1.4	16	....	4	3.75
	10 A. M.	4	1.5	17	....	4	3.75
	11 A. M.	4	1.6	18	....	4	4.0
	12 M.	4	1.75	19	....	4	4.25
May 3	....	4	1.75	20	....	4	4 5
5	....	4	2.0	21	....	4	5.0
6	....	4	2.0	22	....	4	5.0
7	....	4	1 75	25	....	4	7.0
8	....	4	2.12	26	....	4	9.0
9	....	4	2.12	28	....	5	5.0
10	....	4	2.12	30	....	5	9 0
11	....	4	2 25				

Variation of height of water in Hawkeye rice mill well, Fenton, La.

1901.	Hour.	Feet.	Inches.	1902.	Hour.	Feet.	Inches.
Mar. 31	....	14	10	Mar. 7	....	18	3
May 5	....	15	....	8	....	18	2

A. ARTESIAN WELL OF BRADLEY AND RAMSAY LUMBER COMPANY, 1 MILE NORTH OF LAKE CHARLES, LOUISIANA

Flow in March, 1901, 210 gallons a minute

B. SCREEN WOUND AT THE MORESI BROTHERS' SHOP, JEANERETTE, La.
(From Water Supply Paper, 101, U. S. Geol. Surv.)

It will be observed that in these measurements the numbers under feet and inches indicate distances downward from some datum plane, generally the top of the casing or the floor of the discharge trough. As the season advances, the surface of the water in the wells gradually lowers. The rate of lowering is not constant, but the total result of the various fluctuations is to materially lower the water surface as summer approaches. The noticeable acceleration in the rate of lowering after May 15 is due to the beginning of pumping for rice irrigation. Perhaps there is nothing new or unexpected in these results thus far. The variations shown throughout different hours of the day are much more difficult of explanation. Very possibly, though carefully kept barometric readings would give a clew to their meaning.

By far the most interesting and unexpected variations are those of about April 22, 1901, and February 25 to 27, 1902. Instead of the gradual downward course, there is indicated for these dates a noticeable rise. The Weather Bureau reports show that heavy showers were abundant on the 16th, 17th, and 18th of April, 1901, in this part of the State, and from the 19th to the 26th of February, 1902.

Again, these same tendencies toward a lowering in summer and a quick response to local showers has been observed this year (1903), as is shown by the following table :

Date.	May well.	Rice mill.	Planing mill.	Bower's wells.	
				North.	South.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Mar. 19	6.00	....	6.4	....	....
21	5.14	....	6.33	6.73	6.26
25	5.85	6.70	6.50	6.87	6.63
July 12	19.5	18.8	....	19.5	....
13	19.2	....	....	....	....

Over 2 inches of rain fell on the 19th and 20th of March in this vicinity, and from the changes in level noted in the foregoing tables for previous years it is only to be expected that these wells would show a similar change for a similar cause. Observe especially in the May well how the water level rose on the 21st,

but went back again on the 25th. Notice, too, the effect of the summer with its pumping season, under July 12.

The marked effect of copious showers on the water level in the deep wells of southwestern Louisiana has not escaped the general observation of planters.[a]

The extent to which very local heavy showers affect the territory just without their limits is an interesting topic that thus far has not been investigated, nor have time and circumstances permitted the observation of effects produced by local or extensive rainfall in different directions from any given well or group of wells, though the importance of such observations, when a full explanation of the occurrence and conditions of the underground waters of this part of the State is attempted, can not be too much emphasized.

From what has already been said, it is evident that in some respects the waters in this section behave like the common "ground water" of this or any other well-watered land; but that, ordinarily, there is no very direct connection between the water of these deep wells and the ordinary soil supply is evident from the fact that at a number of places the deep waters flow several feet above the surface of the soil for miles around; and, again, the water in the casing of the deep wells never, so far as observed, stands as the same level as the water in the pit outside. Again, the supply of deep water is not obtained until one or, more generally, several, thick, impervious layers of clay have been penetrated.

Since the thickness and character of the sand and clay beds encountered in sinking wells but a short distance from one another may vary greatly, and since the position of a clay bed in one well may be taken by a sand bed in another it is very evident that, in southern Louisiana, the artesian and deep-well conditions are somewhat different from those encountered in regions where there is one great extensive underlying formation, sharply defined from overlying and underlying beds, and alone transmitting the deep underground flow. Yet some typical or ideal artesian features are represented in this part of the State.

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[a] For remarks on this point, see Rept. Geol. Survey Louisiana, for 1902 p. 246.

The first hundred or two hundred feet passed through in sinking deep wells contains comparatively few very porous layers; below, the sand usually becomes coarser, and sometimes thick beds of gravel are found. Gravel deposits are by no means uncommon to a depth of 1,000 feet, as will be seen by inspecting the logs of the wells put down in search for oil or deep artesian water and published herewith as Pl. II. Very coarse gravel is reported in the bottom of many of the best water wells throughout the Gulf border. As will be seen by referring to the record of a well just completed in Biloxi, Miss., the casing, over 900 feet down, is in extremely coarse gravel (see p. 25).

Water naturally flows much more readily through coarse than through fine material. The best flowing or deep wells of southwest Louisiana obtain their waters from very coarse sand or gravel beds. Such beds are generally below 150 or 200 feet from the surface. Ground-water features or characteristics decrease in this region downward, according as those more typically artesian increase.

There is one more somewhat interesting fact connected with variation in pressure head as noticed in the May well at Welsh, though probably it is common to all others in this part of the State. On the 12th of July no pumping was done, and from all appearances none had been done for several days. At 5 o'clock in the evening the water stood 19.5 feet below the top of the mouth of the casing. Next morning the pump had run but an hour when, at the writer's request, it was stopped in order that the stage of the water might be measured. The surface of the water, after dropping suddenly, balanced up and down for a moment and then appeared to have come to rest. Five minutes after the pump had ceased working, the water stood 18.6 feet below the mouth of the casing. After the pump had been stopped for twenty minutes the water stood at 19.2 below the same datum plane. It thus appears that the pumping, which was equivalent to a flow of 1,200 gallons per minute, or 72,000 gallons per hour, had not in one hour's time materially lowered the water level—in fact, had actually raised it temporarily.

That long-continued pumping does lower the level of the water in wells is understood by all who are connected with deep-water

supplies. For example, in July, 1903, Mr. Roane's place was visited,and, although under ordinary circumstances his wells are flowing, at that time, owing to several hours of intermittent pumping, continuing for a period of several days, the water stood just below the tops of the pipes.

The Fabacher well in New Orleans (see p. 42), which ordinarily flows continuously from a 4-inch pipe but 2 feet or less above the general level of the ground, will, if suddenly turned into a smaller pipe, rise up and overflow for a few minutes to a height of 11 or 11.5 feet above the ground. Then the water gradually descends to a permanent head of about 10 feet above the ground. The cause of the temporary, unusually high head in the above-mentioned cases is doubtless attributable to the momentum of the water in the porous sand or gravel bed below. What seems worthy of special note is the length of time required for the water to descend to its normal head, especially in the case of wells that have just been pumped.

WELL DRILLING AND PUMPING

METHODS OF DRILLING

In southern Louisiana practically but one method is used in sinking wells, either for water or oil. This consists primarily of loosening the earth with a hollow revolving bit and bringing it to the surface by the upward current of water obtained by forcing water down through the hollow bit. There are to be sure many different devices for producing the necessary rotating motion, many differently shaped bits, and many different sized and shaped derricks used; but the fundamental principle of drilling is the same with all.

Preferences as to kind and size of well desired differ considerably in different localities. East of the Mississippi and north of Lake Pontchartrain most of the wells are furnished with a 2-inch casing, and the water is expected to flow at the surface of the ground or even some feet above. The wells are used for dairy or ordinary household purposes. West of the delta region the wells are usually 6, 8, 10, or 12 inches in diameter, the water is not expected to rise to the surface, and irrigation is the main object for which the wells are put down. As a result of

the number, kind, and size of wells required in different sections of the State, methods of drilling varying somewhat in detail are resorted to by local drillers.

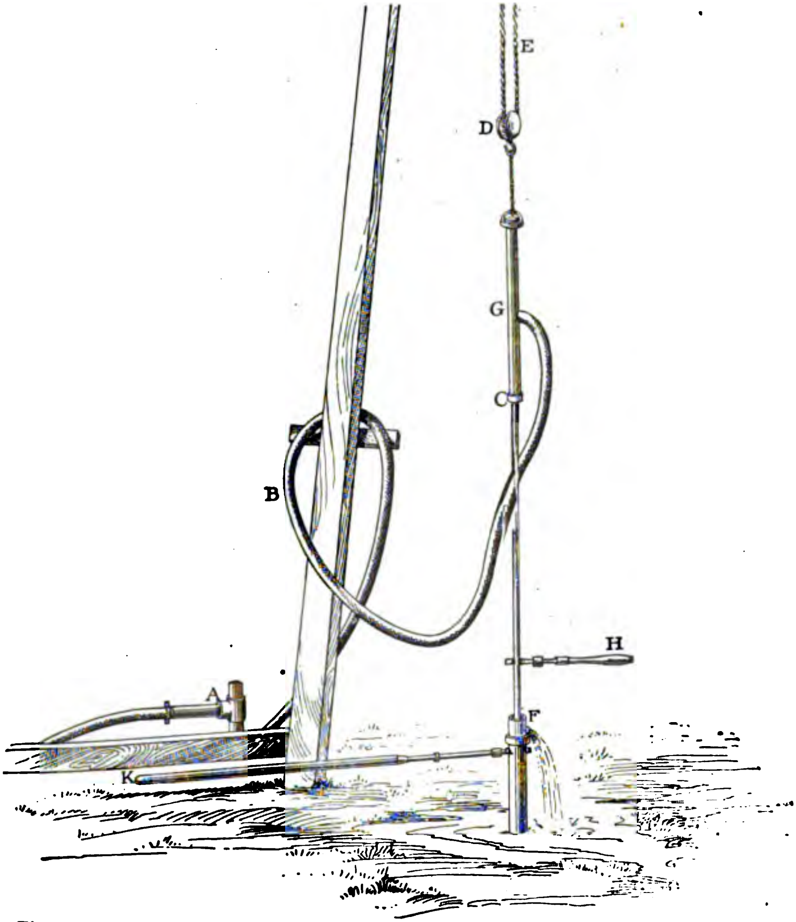

Fig. 10.—Portion of well-drilling outfit of Bacon and Gamble, sinking a well at Ponchatoula by the jetting process.

JETTING

Fig. 10 shows what is usually called the jetting process. The traction engine furnishes steam to run the small force pump (A), which obtains water from a local source and pumps it through a

strong hose (B) to drill pipe (C). The rotating of the pipe with bit attached is here accomplished by the simple method of temporarily attaching a Stilson wrench (H) and moving it to and fro. The pipe carrying the downward current of water with the bit is held up by a block (D) and ropes (E) and is moved up and down every few seconds by power from the engine transmitted by a rope and the force of gravity. The rope going to the engine in this case simply passed over a drum or large spool about 6 inches in diameter, on the outer end of the fly-wheel shaft. Two or three turns only were made around this drum, and when no work was required of the rope the engine continued turning, but the coils were allowed to slip loosely on the drum. By tightening the coils the drill pipe was immediately raised. The drill pipe in this instance is about 1¼ inches in diameter, while the casing is about 2½ inches. The casing is sunk nearly as far as the drill has penetrated, and the return water, laden with drillings, comes up between the pipes. Its exit is shown at F.

By turning back and forth on the long-handled wrench at K the casing is loosened from the outside sand and clay and ordinarily readily descends by its own weight about as rapidly as the jet clears the way, but in some instances is forced down by driving.

As the drill descends and the swivel coupling (G) approaches the top of the casing, the coupling is unscrewed and another length of drill pipe, 12 to 20 feet long, is put in, and the drilling is continued.

ROTARY PROCESS

Where many wells of large diameter are to be put down, as in the southwestern part of the State, much of the manual labor required by the above-described process is done away with by the use of a mechanism for rotating the pipe by steam power. This method is substantially as follows:[a]

A long pit, perhaps 10 feet wide by 20 long, is dug or scraped for a temporary reservoir. This is divided into two compartments, connected, however, in one or two places.

The derrick having been erected and engine placed, a 3-inch pipe with a

[a]Harris, G. D., and Pacheco, J., The subterranean waters of Louisiana: Rept. Geol. Survey Louisiana for 1902, pt. 6, Special Report No. 6, pp. 236–238.

broad bit attached to one end is hoisted up by a rope and drum, and the water hose, of equal size, is attached to the upper end. By a simple device, this pipe is rotated by power from the engine while water is pumped from the pit just described through the hose, down the pipe into the ground. As the pipe descends, the matter disengaged by the bit is washed out and brought to the surface by the jet. When the pipe, say 12 feet long, is sunk into the ground nearly its whole length, another section from 12 to 20 feet long is attached and the rotating and pumping is continued till it too is sunk almost to the surface of the ground. And so the 3-inch pipe is put down till, by the appearance of the sand or the feeling of the pipe when rotated, there is an indication that the water-bearing sand is reached.

Mention should be made here of the care shown in one of the compartments of the pit or pool referred to above, to see that plenty of earth or clay is mixed with the water just before it is pumped through the hose into the pipe. The pressure from the engine pumps is sufficient to force this muddy water into the sandy layers and cause them to stand firmly and not cave as they would be sure to do if only clear water was used. It usually occupies the attention of one man to keep the ingoing waters well stirred up and turbid. The other compartment of the pit contains that portion of the water that has just come out from the well, hence contains the drillings, if such they may be called, derived from the well. The same water as it flows into the first compartment is again used after being properly roiled or mixed with soil.

After the desired depth has been attained, the 3-inch pipe is removed section by section, and the 6-inch, 10-inch, or 12-inch casing is hoisted up and sunk into the hole made by the 3-inch pipe and its arrow-head bit. The hole is often nearly 14 inches in diameter.

The first one, two, or three sections of this large pipe or "casing" are perforated and form the strainer, near the bottom of the completed well. If the strainer is to be three lengths long, say 60 feet, care is taken to insert in the casing three lengths of 3-inch pipe and to fill the space between this inner and the outside pipe with shavings so that it cannot fill with earthy matter while descending. Length after length of casing is screwed on and lowered until the desired amount is sunk into the ground. In case it does not descend readily of its own accord, resort is had to rotating the casing by machinery precisely as the 3-inch pipe was rotated in the beginning. The lower margin of the casing is cut with points like saw teeth, so that it answers fairly well as a drill or auger.[a] The upper end of the 3-inch pipe within carries a conical sleeve, so that it can be caught readily by the thread end of other lengths that are lowered afterwards and coupled up with the three lengths already spoken of as being in the strainer part of the casing. The shavings can now be jettied out, the interior pipe withdrawn, and the well "pumped" to withdraw all the muddy impurities forced down while drilling, as well as fine sand that might eventually fill up the strainer.

[a]Bond, Frank, Irrigation of rice in the United States: U. S. Dept. Agr. Exp. Sta. Bull. No. 113, p. 47.

One of the most satisfactory methods of drilling is by portable outfits, in which the derrick, traction and dummy engines, pumps, etc., are loaded on special carriages. The lightness of this rig and the consequent facility with which it can be moved from place to place tend to make it popular in regions where depths no greater than 300 feet are to be drilled. For various styles of light derricks see the State survey report already referred to(Pls. XLII and XLIII).

If it is expected that drilling will be carried to a depth of 500 or 1,000 feet, larger, stronger outfits are called for. The great advantage of the taller form of derrick is that in hoisting the drill pipe or casing, whenever necessary, it can be uncoupled two lengths at a time instead of length by length, so that nearly half the labor required to remove or replace the pipe is thus avoided.

Oil wells that reach depths of 1,000, 2,000 or even 3,000 feet are put down by similar but heavier outfits. The derrick is sufficiently high to allow the pipes and casing to be removed three lengths at a time.

SCREENS

Nearly every driller has his own ideas as to the proper manner of treating or placing the lower end of the casing so that a well may have a free inflow of water and at the same time may not be liable to clog up. Many assert that all ordinary screens are liable to give out and ruin the wells they are in. No screen at all is most satisfactory if the lower end of the pipe is set in very coarse gravel with no mixture of clay or fine sand. Some advocate the pumping out of several tons of finer material from around the bottom of the pipe and the forcing down, in its stead, of several wagonloads of gravel, so as to make a pebble screen.

As a rule, however, some kind of metallic screen is used. Mr. Bond, in the bulletin referred to above, thus describes a common type in use in southwestern Louisiana :

In the screens now generally used perforations in the well casing are hree-fourths to seven-eighths of an inch in diameter, and the distance between centers averages about 1½ inch, the perforated portion being carefully wound with galvanized-iron wire. On 10-inch pipe No. 14 wire is wound nine wires to the inch ; on 18-inch pipe No. 16 wire is wound eleven wires to the inch ; on 6-inch pipe No. 17 wire is wound fourteen wires to the inch. A common machine-shop lathe is used for winding the wire

A. MAY PUMPING PLANT, WELSH, LA.
Shows general appearance of small stations throughout the rice district of southwestern Louisiana

B. PUMPING [illegible]-INCH WELL ON THE FARM OF A. E. LEE,
[illegible]RTHWEST OF CROWLEY, LA.

upon the casing, and the wire is not only wound on tightly, but is soldered in place to prevent its sliding, so as to close openings between strands. Seven rows of solder are placed upon a 10-inch pipe, the number increasing with larger pipe and decreasing with smaller pipe.

Fig. 11 is taken from Bond's work, and represents the casing, holes, wire, rows of solder as he has just described them.

Pl. VI, *B*, shows a different method of constructing a screen. The wires are wound much farther apart than in the type above described. Over the wires is placed fine brass gauze. The pipe is then wound again over the gauze in the opposite oblique direction. The outside coarse wire is mainly to protect the brass gauze, while the inner coarse wire is to hold the same from fitting down tight upon the interior of the pipe, thus shutting out all ingress of water except immediately over the bored holes.

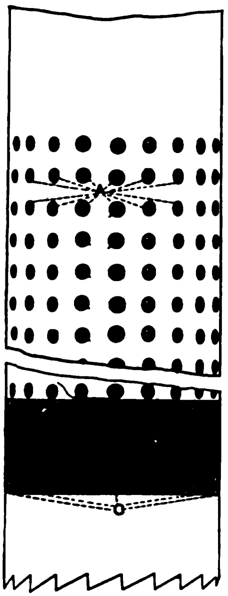
FIG. 11.—A common method of constructing a screen.

Machinists very quickly find it to their advantage to have three to five strands winding at once, side by side, not simply one at a time, as represented in Bond's figure.

The lower end of these pipes is generally closed by a ball valve that is so constructed as to allow the jet of water to pass down and out, but immediately closes against any pressure from below. This is to prevent the entrance of fine sand or other foreign substance.

PUMPING

As would naturally be supposed, water is pumped from deep wells of southwestern Louisiana by steam power. Formerly the fuel used for generating steam was wood from the nearby lowlands or banks of the bayous or coal brought from Alabama or Kansas City by rail. Since the discovery of oil in such quantities at Beaumont, Tex., nearly all the pumping plants have erected tanks at an elevation of from 8 to 10 feet above the boiler furnace, and so are able to store and use oil in a very easy and

economical manner. However, as the price of oil gradually rises above 80 cents per barrel there is a tendency to return to the old methods and materials for making steam. Pl. VII, *A*, shows a typical small pumping plant of today, with its fuel tank and cheap board structure with engine inside.

Pl. VII, *B*, shows the rear of a similar plant. A centrifugal pump (see fig. 12) is on the lower end of the same shaft that carries the band whel. It is placed in a wooden-curbed well

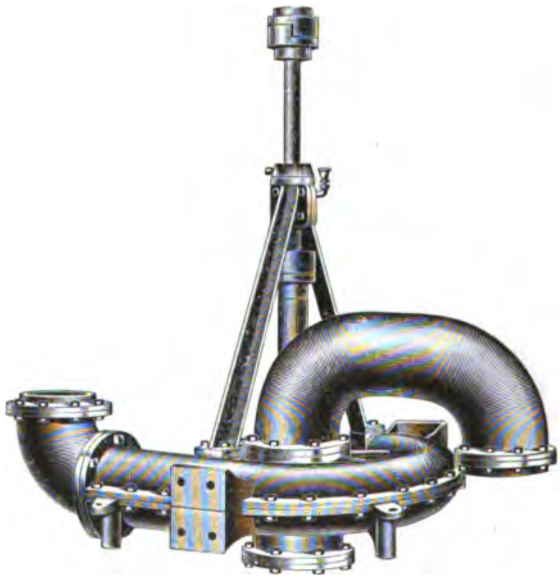

FIG. 12.—Common form of rotary pump. Van Wie Model.

sufficiently low to be beneath the surface of the water at the driest season of the year. When it is not so placed resort must be had to priming every time the pump is started. Around Kinder and China, where the usual head of the water is 25 feet below the surface of the ground, the pumps are depressed to a depth of 25 or 30 feet.

TABLE OF WATER ANALYSES.

Analyses of artesian waters from southern Louisiana

[Parts per million]

Name of well.	Locality.	Solid matter.	Ash.	Organic matter.	Albuminoids.	Free ammonia.	Nitrites.	Nitrates	CaO.	K_2O.	P_2O_5.	Remarks.
A. A. Bayer	Mandeville	208.40	178.4	30.0	0.14	0.04	Trace.	0.8	4 0	4.14	1.19	Colorless, with little suspended matter.
Moresi	Jeanerette	480 0	400.0	80.0	.96	.10	.02	.50	39.40	6.62	.64	Very cloudy.
Moresi (barnyard)	...do.	417.8	366.8	51.0	.02	1.66	Trace.	1.0	91.0	7.95	4.84	Cloudy.
E. Dessome, at flower garden.	Mandeville	179.4	150.4	29.0	.06	.09	Trace.	.2	2.40	6.46	.59	Perfectly clear.
Mrs. Aubert	Abita Springs	184.0	154.0	30.0	None.	.05	.06	.24	.7	4.80	.74	Do.
Hernandez, by house	Covington	161.6	133.0	28.6	None.	.08	Trace.	.4	15.4	8.27	.69	Colorless, with little suspended matter.
Singletry's still	...do.	139.0	117.0	22.0	None.	.01	None.	.72	......	7.34	.48	Colorless, with suspended matter.
Lockmore & Co	West Lake / Lake Charles	268.0	214.0	54.0	.10	.01	None.	.20	44.0	3.16	.42	Colorless, with suspended matter (fishy smell).
Bradley & Ramsay Co.	Lake Charles.	245 0	219.0	26.0	None.	.09	None.	.20	36.0	4.33	.21	Whitish cloudiness.
Reiser machine shop	...do.	260.0	235.0	25.0	None.	.08	Trace.	.52	46.5	3.94	.25	Do.
Menafee Lumber Co.	...do.	271.4	235 0	36.4	None.	.18	None.	.32	33.3	2.52	.42	Slightly cloudy.
Judge E. D Miller	do.	277 0	229.0	48.0	None.	.11	None.	.32	48.2	2.56	.42	Do.
Oaks Hotel	Hammond	185 0	144.6	40.4	.16	.14	.001	.80	5.0	6.98	(a)	Colorless, with suspended matter.
Doctor Robinson	.. do.	187 0	152.0	35.0	.10	.014	Trace.	.28	6.0	.216	3.49	

Owl Bayou Cypress Co.	Strater station	619.0	533.4	85.6	.50	3.08	Trace.	.38	43.30	2.90	3.91
Ponchatoula town well.	Ponchatoula..	205.0	179.0	26.0	None.	.07	Trace.	.48	2.0	1.28	1.02
Biegel's overflow (232 feet deep).	..... do......	237.0	198.0	39.0	.205	Trace.	.60	.80	11.50	1 48	6.40
Biegel's pump well (100 feet deep).	..... do......	512 6	450.0	62.6	.20	1.98	.40	1.0	2.0	10.24	11.64

a Not enough to determine.

PART II

THE UNDERGROUND WATERS OF NORTHERN LOUISIANA AND SOUTHERN ARKANSAS

by

A. C. VEATCH

with a few

INTRODUCTORY REMARKS

by

G. D. HARRIS

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INTRODUCTORY REMARKS

by

G. D. HARRIS

As explained in our preface to Part I, Mr. Veatch was enabled to carry his underground water investigations into Arkansas and adjoining states by aid received from the U. S. Geological Survey. His report, not yet published, will be printed under the auspices of the General Government. The abstract herewith presented, together with the figures and maps give, in a very concise manner the general results of his labors.

Mr. Veatch has been extremely energetic in securing all possible data relating to heights above tide of important points in northern Louisiana. Because of the importance of the same in water-supply discussions, and because we hope soon to commence the construction of detailed topographic maps in this part of the state, we have deemed it advisable to put these elevations in printed form. They accordingly appear as an Appendix to Part II of this Bulletin.

CONTENTS

Part II

ILLUSTRATIONS

Part II

THE UNDERGROUND WATERS OF NORTHERN LOUISIANA AND SOUTHERN ARKANSAS

By A. C. VEATCH

TOPOGRAPHY AND STRATIGRAPHY

The area included in this report, all of Louisiana and that part of Arkansas south of the Arkansas River and the Mountains, has the same general structure as the great American Coastal Plain, of which it forms a part. The land is higher towards the old plateau and mountain region, and the beds are for the most part unconsolidated, succeed one another more or less regularly, range in age from the Cretaceous on the one hand to the recent shore deposits on the other, and dip in a general way coastward at a rate greater than that of the land surface. This relation of dip to surface slope supplies conditions which are favorable for artesian water and we should, therefore, expect to find flowing wells in many parts of the Coastal Plain. In some cases, although the height of the point at which the well is sunk is less than the height of the region where the sands come to the surface and where the water enters it, the leakage and resistance of the sands so reduces the pressure that the water will not flow; in others, erosion has so changed the surface of the plain that the point at which the well is sunk, though south of the outcrop, is higher and flowing water, therefore, is impossible. In Louisiana and Southern Arkansas there is, in the older beds, in addition to the slope toward the coast, a slope toward the Mississippi Valley. Some of these older beds are very much disturbed, forming peculiar, sharp, coned-shaped domes, and as these layers often contain artesian salt water, and are frequently broken by the high folding, the salt water is free to pass into the sands of the surrounding younger formations, introducting a very unsatisfactory condition into the water prospects of the region. While these domes disturb the conditions in certain areas, there are still larger

areas in which wells have yielded good water. A study of well records and the general structure of the country has shown the following principal water horizons:

Pliocene and Pleistocene sands and gravels.

Catahoula (Grand Gulf) sandstone.*

Sabine (Lignitic sand.)†

Nacatoch (Washington) sand.‡

Bingen sand.**

The relation of these beds, one to another, is shown in (Pl. X) and their geological age and relation to adjacent beds is shown in Table I.

* Name proposed from typical development of formation in Catahoula Parish, La., and used for the lower or typical Grand Gulf of Hilgard as exposed at Grand Gulf, Miss. It includes the sandstone bearing clays between the Vicksburg and Fleming Oligocene.

† Adopted to supplant the name Lignitic. Name taken from typical Fossiliferous development of this formation on the Sabine River, in Sabine County, Texas and Sabine Parish, La.

‡ Name taken from typical exposures at Nacatoch bluff on the Little Missouri river in Clark Co., Ark.; and includes the sandy beds between the Marlbrook and Arkadelphia, called Washington Greensands by Hill, which name is preoccupied.

** Name used by Hill for beds which he doubtfully referred to the Eocene. These, with the exception of a single Nacatoch outcrop which was incorrectly included in this series, are now known to pass beneath the Brownstown and to represent the littoral beds of the bosal upper Cretaceous.

GEOLOGIC FORMATIONS

List of formations in Louisiana and southern Arkansas with notes on their water-bearing value

TABLE I

Periods of formation		Maximum thickness	Water-bearing value
Pleistocene		2000*	Contains gravel and sand beds which furnish the main supply of water in southern Louisiana. As superficial deposits on the uplands and in the valleys, supply much of the shallow well water of this region.
Pliocene			
Miocene		?	Not known. Water probably salty.
Oligocene	Fleming (Frio)	200†	Clays and marly clays of no water-bearing value.
	Catahoula	1000†	The coarser sandstone layers of this formation furnish excellent waters. Three or four horizons have been developed.
	Vicksburg	50–100	Exposed only to a limited extent in one part of the area and of no importance from a water standpoint.
Eocene	Jackson	500	Clays and clay marls with occasional sand beds; water seldom found and generally hard.
	Cockfield Member of the Claiborne	600	The sands of this formation are water bearing but are generally not so economically important as those in the Sabine.
	Lower Claiborne	500	Clays and clay marls containing sand beds of little importance as water horizons.
	Sabine	1000	The sands of this formation are the most important water horizons of the greater part of northern Louisiana and adjacent portions of Arkansas.
	Midway	?	Exposed only to a limited extent in one part of the area, and of no importance from a water standpoint.
Upper Cretaceous	Arkadelphia	600	Clay beds which serve to retain water in Washington sands.
	Nacatoch	150–200	One of the most extensively developed water sands of this region. Very good water toward outcrop, but becomes brackish in the imbed.

*Harris G. D. Organic Remains from the Deep Well at Galveston. Fourth Ann. Report, Geol. Survey of Texas, 1893, p. 118. Harris, G. D. Report of La. Geol. Survey for 1902, p. 32.

†Based on dip calculations on the Sabine River and on the thickness of these beds in the Alexandria, La., wells. 800 + feet.

TABLE I—*Continued*

Periods of formation		Maximum thickness	Water-bearing value
Upper Cretaceous	Marlbrook	400	Clays, clay marls and chalk; serve to retain water in the Bingen sands.
	Annona	100†	
	Brownstown	300	
	Bingen	500	Persistent sandy beds, furnishing water over a wide area.
Lower Cretaceous		550†	Is not known to contain any water-bearing layers of importance in this region, though the great development in eastern Texas would lead us to expect some development here.
Paleozoic		?	Hard rock layers very much disturbed. Contains water, but its occurrence cannot be predicted until the geology of the region is minutely understood. In general not very good field for water wells.

† Hill, R. T. "The Mesozoic Geology of southern Arkansas." (Ark. Geol. Surv. Ann. Rept. 1888, p. 188.)

WATER HORIZONS

LOWER CRETACEOUS

The Lower Cretaceous occupies the wedge-shaped territory between the Paleozoic rocks and the Bingen sands (Pl. VIII). All deep wells in this region have thus far failed to yield results, though the extensive development of water sands in this group in Texas leads us to expect that further attempts, especially in the western part of the State, will not be fruitless.

BINGEN SANDS

The Bingen sands come to the surface along and north of the line shown in Pl. VIII. Along this line shallow wells are, therefore, the rule, but as the sand dips at a rate of 50 to 75 feet per mile in a southeasterly direction, the wells become deeper in passing southward, until an extreme depth of 784 feet is reached near Columbus, a little north of the outcrop of the Nacatoch sand. Some failures have been reported in the southern part of this territory, notably at Columbus and Washington but in each case the failure was due to the fact that the wells were abandoned before the required depth had been reached. The greatest development has naturally been in the region where flowing water can be

obtained (Pl. IX). The maximum depth to which wells will be driven in this region will probably not exceed 900 feet, as before this depth will become necessary the Nacatoch sands will appear on the surface, making shallow wells possible.

The water is very soft, and somewhat alkaline, except in wells which do not flow and have only been partially cased, and in which the water therefore stands in contact with the overlying calcareous clays. Hard water has been found in a few wells, as at Hudson and near Burtsell, but in these cases it to occurs in the calcareous beds which overlie the Bingen sands, and the indications are that if the wells had been deepened 200 or 300 feet they would have reached the Bingen and obtained soft water.

NACATOCH (WASHINGTON) SAND

This sand, like the Bingen, is of very great economic value to a large section in southern Arkansas, where it is practically the only available source of well water. The regions underlain by the Bingen and Nacatoch sands are both regions of rich calcareous clays, with here and there thin coatings of younger gravel, and the surface water is generally hard and very unsatisfactory. Persistent water-bearing horizons, whose features are so well understood that the depth to water can be predicted at any point, and which will furnish soft artesian water over wide areas, cannot fail to have a great effect on the development and land values of the regions which they underlie.

The Nacatoch sand has been extensively developed along the line of the Iron Mountain railroad from west of Red River almost to Arkadelphia (Pl. VIII). It dips southeastward at a rate of from 50 to 100 feet per mile, until it reaches a point about 800 feet below sea level, when it abruptly becomes horizontal and continues so to a point somewhat south of Shreveport, where it again slopes normally coastward (Pl. X).

The extensive horizontal distribution would make this sand of great value over wide areas, were it not for the fact that south of a line which runs irregularly from 3 to 15 miles from the outcrop the water is quite salty. Seemingly, that portion of the sand near the outcrop has been thoroughly washed by percolating waters, whil that less favorably situated is in its original salty

condition,—a condition which may even have been increased by the salts washed down from the upper layers. Wells at Texarkana, Jefferson, Shreveport and Frierson, have yielded impotable water, which at the last three places is artesian, indicating an artesian basin covering a considerable part of the Red River Valley. (Pl. IX.) A part of the brine which occurs in some of the Cretaceous uplifts in northern Louisiana is likewise from this horizon. In general it is felt that that portion of the sand which lies south of the shaded area in Pl. VIII will not furnish potable water.

SABINE (LIGNITIC)

Under this head is classed not a single well defined horizon like Nacatoch, or Bingen, or other Cretaceous horizons but a number of somewhat irregular water sands occurring throughout a formation which in the western part of this area attains a thickness of perhaps 1000 feet. The lowest of these sands occurs about 700 feet above the Nacatoch, and like it, is very nearly horizontal over a considerable area (Pl. X). Eastward and southward this bed dips gently towards the Mississippi Valley and the coast. Other sand beds occur in the formation above this one, at varying distances from each other, and of varying thickness. As many as nine have been developed at Plymouth, La., and six at Ruston. These beds thin and thicken very rapidly, so that in one well a good water sand may be found which in a nearby well is too thin to give results. Wells, then, show considerable irregularity in depth, some wells furnishing one bed and some another; but in general the wells, are deeper to the southward and towards the Mississippi Valley, as in each case the dip carries the sands beneath younger beds, and it becomes necessary to pass through a certain thickness of overlying deposits even to reach the top-most water sands of this series. Thus at Winnfield it is 600 to 700 feet to one of the principal sands, while at Colfax only the base of the Cockfield is reached at 1100 feet.*

While these sands may generally be found in the area indicated in Pl. VIII and will produce flowing water in the areas shown in Pl. IX several failures have been reported. Those at Best and Crossett, Ark., and Vicksburg, Miss., are doubtless due to local

*This is incorrectly shown as Sabine on Pl. X.

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show little regularity and the better wells have, almost without exception, been finished in the main horizon.

The outcrops of the Cockfield sands in Arkansas and Louisiana are all relatively low, and the water will generally not rise much above 100 feet above sea level. Flowing wells will be obtained along the main stream channels in central Louisiana. In Arkansas and northwestern Mississippi the artesian area is near the eastern side of the flood plain where a relatively higher head is developed because of the greater average height of the Mississippi hill lands. Water will rise very near the surface over all the flood plain, but in Arkansas it is regarded as quite impossible that flowing wells will be obtained.

JACKSON

Beds of this age generally furnish hard water, and are, therefore, not extensively exploited.

CATAHOULA (GRAND GULF)

The sands and sandstone of this formation are good water-carriers and have yielded excellent results in central Louisiana, where they furnish flowing wells at Zimmerman, Boyce, Alexandria, Pollock, and Harrisonburg. Several horizons have been found which furnish soft water of a very good quality and we feel that over a considerable area along the Ouachita and Black rivers and about Catahoula Lake and Littleriver, (Pl. IX) flowing water is to be expected from these sands. Flowing wells will doubtless be obtained in Sabine River valley below the outcrop of the Grand Gulf, as indicated by the water obtained from these beds on the Angelina near Rockland, Texas, but in the high hill region about Leesville the wells will probably be quite deep, and the water will have to be lifted some distance.

PLIOCENE AND PLEISTOCENE GRAVELS

These sands and gravels underlie a large portion of southern Louisiana, and are doubtless to be regarded as the most important water horizon in the State. The outcrops on the hill lands are large, and therefore the amount of rain-water passing into them is great. Covered with the more recent coastal clays they

furnish artesian water over considerable areas—(Pl. IX), and over still larger areas (Pl. VIII) the water rises so near the surface that it is readily available for irrigation and other uses.

Under the main river valleys in northern Louisiana and southern Arkansas there are thick deposits of sand and gravel partially filling the old valleys. In these, limited supplies can be obtained from driven wells of no great depth, but when large supplies are needed wells should be pushed to the main gravel bed which overlies the older Cretaceous and Tertiary strata. This can be reached at depths ranging from 75-150 feet.

In the Mississippi bottoms, and sometimes toward the coast, the water in these beds is generally so charged with various soluble salts that it is of little value.

APPENDIX TO BULL. I. PT. II.

A DICTIONARY OF ALTITUDES IN NORTHERN LOUISIANA

BY A. C. VEATCH

CONTENTS

CONTENTS—*Continued.*

STRATIGRAPHY OF LOUISIANA AND SOUTHERN ARKANSAS.

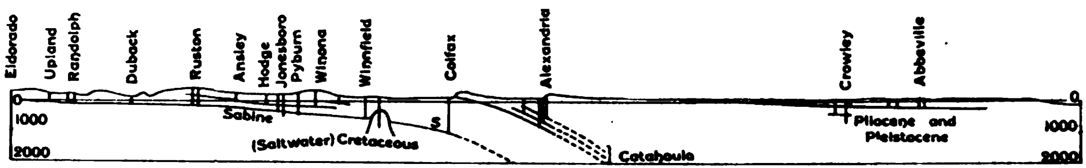


Fig. 1.—Section from Lockesburg, Ark., to Cameron, La., (along line A—A, Pl. VIII), showing water horizons.

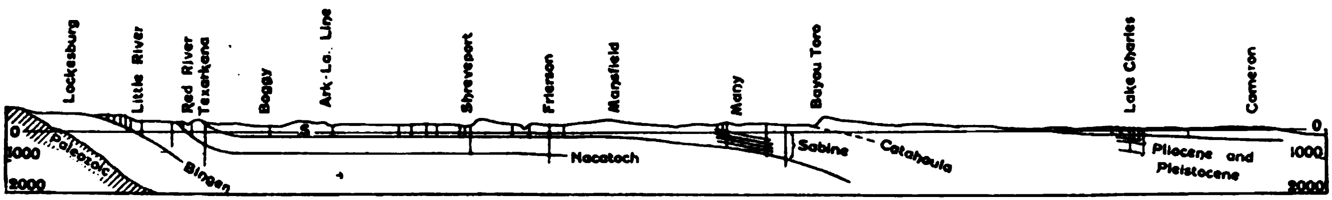


FIG. 2.—Section from Eldorado, Ark., to Abbeville, La., (along line B—B of Pl. VIII), showing water horizons.

INTRODUCTION

Relative elevations are of such importance in the solution of problems relating to geology, and especially underground waters, that a list of altitudes becomes an imperative necessity in such investigations.

This region is particularly fortunate in having a very complete net of precise levels from which railroad elevations can be so corrected that the error at any point is comparatively small. In order that this error may be decreased still further a discussion of the nature of the corrections applied in the compilation of this dictionary is given below, from which a readjustment will be possible when more data are accumulated.

SOURCES OF DATA

ALEXANDRIA AND WESTERN R. R.

Elevations accredited to this source are from a small scale profile, kindly furnished by Ira W. Sylvester, C. E., of Alexandria, Louisiana, of a preliminary line running from Alexandria to the junction of the Quelqeshoc (also called Calcasieu River) and Cypress Bayou in T. 2 N. R. 4 W., thence through Walnut Hill to about the present site of Orange and southward to a point on the Sabine River about one mile south of Toledo. As this survey started from the U. S. E. bench-mark at Alexandria the only correction applied was that necessary to reduce Cairo datum to mean gulf level (—20.280 feet). Because of the small scale of the profile the elevations have an error of 11.0 feet.

ARKANSAS SOUTHERN R. R.

These elevations were taken from the fragmentary original field profiles in the company's office at Ruston, La., September 26, 1902. They have been corrected in accordance with the following data:

Top of rail V. S. & P. crossing (from U. S. E. bench)	304.47 ft.
Top rail of V. S & P. crossing Arkansas Southern profile	313.60 ft.
Difference	—9.13 ft.

These levels, as a whole, can be regarded as only approximate. At Winfield a rough comparison indicates that the Arkansas Southern levels, as corrected, are five feet higher than those of the Arkansas and Louisiana R. R. This additional correction was not used, however, because of its uncertain value.

HOUSTON AND SHREVEPORT R. R.

These elevations were received from Mr. I. A. Cottingham, Engineer Maintenance of Way, in 1904. The approximate correction applied depends on the following:

Grade elevation K. C. S. and H. & S. crossing, from corrected K. C. S. profile	234. ft.
Grade elevation K. C. S. and H. & S. crossing, from H. & S. levels	228.5 ft.
Correction	+5.5 ft.

KANSAS CITY SOUTHERN

Elevations accredited to this source are of two classes:

1. Those marked "P" are from a line of levels beginning at the U. S. C. & G. Survey bench mark on the Hannibal and St. Joseph R. R. bridge at St. Joseph, Mo., running along the track to Lake Charles, La., and Port Arthur, Texas. Rail and benches were placed every half mile. The error of closure with the top of boss of the U. S. E. bench mark in the postoffice yard at Shreveport, La., was as follows:

Elevation corrected by Hayford *	199.744 ft.
Elevation according to K. C. S. precise levels	201.785 ft.
Difference	—2.041 ft.

In the elevations given in the accompanying table, which extend from Gillham, Ark., to De Ridder, La., this correction has been applied as a constant, no attempt having been made to distribute the error.

2. The elevations marked "R" are from the profiles made at time of the construction of the road; those in Arkansas from copies in the office of the district engineer at Texarkana, and those in Louisiana from copies furnished by the chief engineer to the Geological Survey of Louisiana. Corrections for the profiles south of Texarkana depending upon the following:

AT SHREVEPORT, LA.**

Zero city datum (161.27 ft. Cairo datum —7.18 ft.)	133.81 ft. (Gulf level.)†
Zero city datum (K. C. S. profile levels)	221.9 ft.
Difference	— 88.1 ft.

AT MOORINGSPORT, LA.

Draw-span Ferry Lake Bridge (K. C. S. profile)	286. ft.
Top of rail Draw-span Ferry Lake Bridge (elevation boss of U. S. E. bench Mooringsport + 11.730 ft.)	198.933 ft.
Correction for top of rail elevation	— 87.067 ft.

As these two lines show an essential agreement a correction of —88 ft. has been applied for ground level, and —87 ft. for top of rail.

KANSAS CITY, WATKINS AND GULF R. R.

The levels along this line have been taken from Bulletin No. 160 without alterations.

* Ann. Rept. Supt. Coast and Geodetic Survey for 1899, pp. 493, 670, 1900.

** Louisiana Geol. Survey Rept. for 1889, pp. 203-204, 1899.

† Ann. Rept. War Dept., Rept. of the Chief of Engineers, 1902, pt. 2, p. 1448, 1902.

LOUISIANA AND ARKANSAS R. R.

The elevations given are the corrected values received from Chief Engineer, Col. G. Knobel, September 2, 1904, which depend on the value of the Hope U. S. Geological Survey bench mark of 356 feet. As the corrected value of this bench is 356.8 feet, one foot has been added to all the elevations. A comparison with the U. S. E. bench mark at Sibley (Lanesville), La., suggests that an additional correction of about + 1 foot should be applied south of that point.

LOUISIANA RAILWAY AND NAVIGATION CO.

(Red River Valley R. R.)

The elevations were obtained from profiles in the office of the Chief Engineer at Shreveport, La., Oct., 1902.

All elevations between Shreveport and Colfax have been changed by adding 2.7 ft., as a note on the profile at St. Maurice reads "Add 1.76 ft. to reduce to M. G. D.—J. M. P." Since this depended on the old value for Cairo datum (—21.26 ft.*), it is necessary to add to it 0.98 ft. to reduce to the new value for Cairo datum (—20.28 feet.†)

Between Colfax and Bordelonville a correction of +0.91 ft., has been applied which depends on the following values :

ALEXANDRIA TO COLFAX

High water at Alexandria, 1892, (profile)........	81.5 ft.
" " " " " (U. S. Engineers).	82.41 ft.‡
Correction............................	+0.91 ft.

ALEXANDRIA TO BORDELONVILLE

Elevation boss U. S. E. pipe-stone bench in old Jail yard, Alexandria...........................	74.00 ft.
Elevation boss U. S. Engineers.................	74 918 ft.§
Correction............................	+0.91 ft.

The same correction has been applied on the Colfax-Winnfield line.

* Ann. Rept. Chief Engineers for 1893, p. 2064, 1893.

† Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1448, 1902.

‡ Ann. Rept. Chief of Engineers for 1893, p. 1982, 1893.

§ Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1458, 1902.

MISSOURI, KANSAS, AND TEXAS, R. R.

The elevations accredited to this source are taken from a profile furnished in 1898 by Maj. B. S. Wathen, Chief Engineer of the Texas and Pacific R. R. The portion of the line from Shreveport to the Texas line was at that time leased by the T. & P. The correction applied to reduce this to mean gulf level depends on the following:

Elevation top of rail at K. C. S. crossing near Stock-yards, Shreveport, (K. C. S. corrected profile)..	238.9	ft.
Elevation top of rail (M. K. T. profile)..........	239.50	ft.
Correction for top of rail elevation.........	—0.6	ft.

NEW ORLEANS AND NORTHWESTERN R. R.

Data along this line were taken from the profiles in the office of H. Rohwer, Chief Engineer of the Missouri Pacific System, at St. Louis. A comparison of the stations below Rayville with the U. S. E. bench marks shows a correction of approximately +15 ft. This has been applied to all elevations.

OLD RIVER AND KISATCHIE R. R.

The elevations along this line were obtained from the General Manager in September, 1902, and were corrected on the assumption that the elevation of the top of rail T. & P. R. R. at Old River station is 100 feet above sea level.

ST. LOUIS, IRON MOUNTAIN AND SOUTHERN R. R.

Main line.—The elevations from the Hot Springs Clark Co. line to Texarkana are taken from a detailed profile, kindly loaned by Chief Engineer H. Rohwer. Lines of levels from the U. S. G. S. bench marks at Gurdon, Prescott and Hope give the following corrections for top of rail elevations:

Gurdon..................................	+103.06 ft.
Prescott................................	+103.10 ft.
Hope....................................	+103.03 ft.

The value, +103.1 has been taken.

Little Rock to Alexandria, La., "Valley Road."—The section of the profile from Pine Bluff north has not been corrected other than to add one foot for top of rail elevation. On this the eleva-

tion of the depot at Little Rock is given as 268 ft.; the St. Louis Southwestern crossing at Pine Bluff 227 ft.; and the depot at Pine Bluff 214 ft.

The section from Pine Bluff to McGehee has been corrected according to the following:

Approximate elevation top of rail McGehee station *.	150. ft.
Profile elevation McGehee station................	147.5 ft.
Difference..............................	+2.5 ft.

From Riverton to Alexandria elevations were taken from profile dated Oct., 1895, and endorsed "Built in 1892." The correction depends on the following:

Near Riverton, Caldwell Parish, La.

R. R. bench mark at Smith Lake................	72.16 ft.
Elevation of same, U. S. Engineers †...........	66.722 ft.
Correction..............................	—5.4 ft.

RED RIVER BRIDGE AT ALEXANDRIA

High water June 11–14, 1902, (profile).........	85.5	ft.
" " " " " (U. S. Engineers)	83.3	ft.‡
Correction............................	—2.2	ft.

These corrections have been applied at the point indicated, and points between have been corrected according to their proportional distances.

ST. LOUIS, SAN FRANCISCO AND NEW ORLEANS R. R.

(Arkansas and Choctaw R. R.)

The elevations from Ashdown to Hope were obtained from the Division Engineer, Jas. Harrington, in December, 1902. The initial point of these elevations was the Kansas City Southern rail end bench at mile post 468 at Ashdown, which was given an elevation of 330.69 feet, (corrected from Shreveport=328.65.)

The difference at Hope was:

* Elevation given by Gannett on authority of U. S. C. & G. S. plus correction from readjustment of levels by Hayford.

† Ann. Rept. of Chief of Engineers for 1902, pt. 2, p. 1475, 1902.

‡ Ann. Rept. of Chief of Engineers for 1893, p. 1983, 1893.

Elevation U. S. G. S. BM on Bank Building by A. & C. levels	359.34 ft.
Elevation U. S. G. S	356.81 ft.
Correction for A. & C. levels	—2.53 ft.

This correction has likewise been applied to the station elevations furnished by Chief Engineer, J. F. Hinckley.

ST. LOUIS SOUTHWESTERN R. R.

All elevations given are taken directly from Gannett's dictionary of altitudes.*

A comparison with the U. S. E. benches along the same line indicates an error of ± 5 ft.

SIBLEY, LAKE BISTINEAU AND SOUTHERN R. R.

Data obtained from the company's office at Yellow Pine, through the kindness of Mr. J. W. Martin, Gen'l Manager. The relation of the line to the U. S. E. bench mark at Sibley (Lanesville) is not known, as there is no record of elevations of the portion of the line from Sibley to Yellow Pine. The correction applied depends on the following:

Elevation south head block at L. R. & N. Co. depot Coushatta	141.1 ft.
Elevation according to L. R. & N. Co. corrected profile	144.74 ft.
Correction	+3.6 ft.

TEXAS AND PACIFIC R. R.

In the absence of satisfactory correction data the elevations at stations along the T. & P. are given exactly as received from Chief Engineer, B. S. Wathen. Comparisons at Shreveport indicate that the error is not greater than 1 or 2 ft. The data in Caddo Parish is from a profile furnished by the Chief Engineer, which has been corrected to agree with the following:

Elevation Reisor	190.4 ft.
" " (profile)	155 9 ft.
Correction	+34.5 ft.

*Gannett, Henry, Dictionary of Altitudes in the U. S., 3d edition, Bull. U. S. Geol. Survey, No. 160, 1899.

U. S. SURVEYS

U. S. COAST AND GEODETIC SURVEY

The elevations given refer to those of the Vidalia-Smithland, Vicksburg-Vidalia, Wilkersons-Vicksburg and Little Rock-Wilkersons lines as corrected by Hayford in 1900.*

Bench Marks.—The permanent bench marks encountered on these lines are of the following classes, unless otherwise described:

1. Stone posts dressed to 5x5 inches, or 6x6 inches at the top, projecting a few inches above the surface, marked, either;

U. S.	U. S.	U. S.
□	B □ M	B □ M
BM	1880	1881

The bottom of the square cut in the top of the stone is the bench.

2. Copper bolts leaded in masonry either horizontally or vertically. If horizontal the bench is the center of the bolt or the center of the cross cut of the bolt; if vertical, the top of the bolt.

U. S. ENGINEERS

The elevations accredited to this source are from the reports of the Chief of Engineers for 1893 and 1902.†

On the precise lines from Delta to Coushatta, Coushatta to Grand Bend, Grand Bend to Smithland, Monroe to mouth of Black River, Monroe to Little Rock, Camden to Shreveport, Rayville to Concordia, Parkville to Greenville via Arkansas City, Glendora to Farmerville, Delhi to Tensas River, Archibald to Bellevue and Three Rivers, Gilbert to New Light, Shreveport to Jeter's Landing, and Baskin to mouth of Black River, the elevations are the mean gulf elevations given in the Engineers Report for 1902. A reduction of these values to the precise level net of the Coast Survey was published by Hayford in 1900, to which the reader is referred.‡

The elevations along the line from Fulton to Shreveport and of the high and low water marks, which in the Engineers

*Rept. Supt. Coast and Geodetic Survey for 1899, pp. 482–485, 607–613, 1900.

†Ann. Rept. of the Chief of Engineers for 1893, pp. 1953, 1956–57, 1973–74, 1982, 2064, 1893. Ann. Rept. of Chief of Engineers for 1902, pp. 1448–1453, 1902.

‡Report Coast and Geodetic Survey for 1899, pp. 482–483, 607–613, 1900.

Reports are expressed in meters above Cairo datum, have been reduced, by using the following values: 1 meter=3.280833 ft.;* mean gulf level=+20.28 ft.† Cairo datum.

Bench Marks.—The bench marks of the U. S. Engineers are of the following classes:

1. Pipestone benches; pieces of limestone 46 centimeters square, 16 centimeters thick, marked $\overset{\text{U. S.}}{\underset{\text{B. M.}}{\circ}}$ with spherical-headed copper bolts leaded in upper faces and buried 1.2 meters under ground, access being given through 12-centimeter iron pipes set on top. Each pipe has a cast-iron cap, fastened by a horizontal bolt through cap and pipe. The cap has a small boss and the letters $\overset{\text{U. S. E.}}{\underset{\text{B. M.}}{\circ}}$ raised on top. Elevations apply to the top of the bolt in the underground stone. Elevation of boss of pipe cap can be found in any case by adding 4.066 ft. to elevation of copper bolt.

2. Pipe-flange benches. These consist of 4-centimeter gas pipes about 1.6 meters long, capped at upper end and having a 12-centimeter circular flange attached near lower end by lock nuts. Monuments set with about 0.1 meter above ground surface. Flanges are surrounded in the usual case by a matrix of neat cement, approximately doubling the bearing area of the monument. Elevations apply to the top of cap.

3. Root benches. Temporary benches generally consisting of a nail in a knuckle chopped in the root of the tree. On many trees the letters U. S. have been cut or branded above the bench.

U. S. GEOLOGICAL SURVEY

The elevations given are the results of the precise levels run in connection with the survey of the Camden, Gurdon and Caddo Gap quadrangle, adjusted by Mr. D. H. Baldwin, August, 1904.

Bench Marks.—Permanent bench marks are of two types:

1. Iron posts. These are hollow wrought iron posts 4 ft. 6 in. in length, 3.5 inches in outer diameter, split at the bottom and expanded to 12 inches, to prevent the easy subsidence of the

*Bull. U. S. Coast and Geod. Survey, November, 1901.

†Ann. Rept. Chief of Engineers for 1902, p. 1448, 1902.

post, or its malicious disturbance. In the top of this post is riveted a bronze tablet 3.5 inches in diameter, one-fourth inch thick. These posts are buried in the earth with only one foot of their length projecting above the surface. The intersection of the cross is taken as the bench mark.

2. Tablets. Metal tablets fastened with portland cement into rock or masonry structures. The bench mark is the intersection of the cross lines.

VICKSBURG, SHREVEPORT AND PACIFIC R. R.

These elevations were received from resident Engineer, L. W. Stubbs, in Nov., 1898, expressed in feet Cairo datum. A connection with the U. S. E. gauge at Shreveport, by city Engineer Cain, made Nov. 22, 1898, gave the following correction:

Top of rail south end V. S. & P. Bridge, from U. S. E. gauge	189.32	ft.
Top of rail "Red River Bridge"	206.4	ft.
Correction	— 17.1	ft.

This correction has been applied throughout and the error is probably ± 3 ft. More exact elevations, however, may be had along this line in the permanent reference points of the U. S. Engineers.

ABBREVIATIONS

The elevations given below vary greatly in accuracy and they have been divided roughly into the following classes :

P. = Precise levels of the U. S. Engineers, U. S. Coast and Geodetic Survey and U. S. Geological Survey.

E. = Engineers levels. Levels run by U. S. Engineers but not classed by them as precise. In general, more accurate than railroad levels.

R. = Railroad levels. As there is no economic need for extreme precision in elevations in railroad constructions, these levels, as a rule, may be regarded as only approximate. The error, however, is relatively small and need not be considered in most of the geologic and water problems involved in this area.

L. = Reconnaissance levels. Included in this head are preliminary surveys for railroads and other miscellaneous lines controlled by spirit level surveys. As a rule, less accurate than the three foregoing classes.

A. & W. .... Alexandria and Western R. R.
A. & L. .... Arkansas and Louisiana R. R.
A. S. .... Arkansas Southern R. R.
H. & S. .... Houston and Shreveport R. R.
K. C. S. .... Kansas City, Southern R. R.
K. C. W. & G. .... Kansas City, Watkins and Gulf R. R.
L. & A. .... Louisiana and Arkansas R. R.
L. R. & N. .... Louisiana Railway and Navigation Co.
M. K. & T. .... Missouri, Kansas and Texas R. R.
N. O. & N. W. .... New Orleans and Northwestern R. R.
O R. & K. .... Old River and Kisatchie R. R.
P. B. & W. .... Pine Bluff and Western R. R.
St. L. I. M. &. S. .... St. Louis, Iron Mountain and Southern R. R.

St. L. S. F. & N. O. .... St. Louis, San Francisco and New Orleans R. R.
St. L. S. W .... St. Louis, Southwestern R. R.
S. L. B. & S .... Sibley, Lake Bisteneau and Southern R. R.
T. & P .... Texas and Pacific R. R.
U. S. C. & G. S .... U. S. Coast and Geodetic Survey.
U. S. E .... U. S. Engineers.
U. S. G. S. .... U. S. Geological Survey.
V. S. & P .... Vicksburg, Shreveport and Pacific R. R.

LIST OF ELEVATIONS

LOCATION	AUTHORITY	CLASS	ELEV'N
AVOYELLES PARISH			
Atchafalaya River, WATER VALLEY LANDING; pipe-stone bench on Tom Carruth's plantation	U. S. E.	P	42.712
Bayou des Glaises, LEMOINE'S FERRY; 1 mile above, root bench in locust 115 feet from Tony Lien's dwelling	U. S. E.	P	53.959
——LEMOINE'S FERRY; 115 feet above, root bench in chinaberry on left bank	U. S. E.	P	56.558
——MOREAUVILLE; Rabelais' plantation, copper bolt in chimney of cabin, 100 feet from bayou	U. S. E.	P	61.255
——PAVEY PLANTATION; copper bolt in chimney of cabin of Bazil François, 0.3 mile southeast of Hamburg, 200 feet from bayou	U. S. E.	P	55.695
——NORWOOD'S PLANTATION; copper bolt in chimney of cabin about 575 feet east of Harlands Bayou	U. S. E.	P	50.515
Bayou Choctaw, L. R. & N. BRIDGE; Sec. 8, T. 1 N., R. 3 E., top of stringer	L. R. & N.	R	63.4
—— ——bank of bayou	L. R. & N.	R	51.
—— ——bed of bayou	L. R. & N.	R	36.
Bordelonville; grade center of station	L. R. & N.	R	50.4
Bunkie; grade center of station	T. & P.	R	65.7
Cocoville; root bench in black locust 156 feet southeast of Avnes Collan's residence	U. S. E.	P	72.541
Cypress Bayou; on southeast bank of, root bench in pecan, 165 feet northeast of Mansura-Moreauville road	U. S. E.	P	50.670
Egg Bend P. O.; root bench in locust at foot of levee opposite story	U. S. E.	P	63.156
Grand Ile; ground at summit	L. R. & N.	R	83.
——grade at summit	L. R. & N.	R	71.
Hamburg; 0.3 mile southeast of, on Paveys plantation, copper bolt in chimney of cabin of Bazil François, 200 feet from Bayou des Glaises	U. S. E.	P	55.695
Hessmer; grade center of station	L. R. & N.	R	78.2
Mansura; copper bolt in northwest pier of gallery of David Siess' store	U. S. E.	P	76.422
——near southern limits, copper bolt in chimney of Mme. V. Claude's residence	U. S. E.	P	79.686
——T. & P. crossing	L. R. & N.	R	78.3
——east of summit of Contee des Gres	L. R. & M.	R	83.4
Marksville; north end, root bench in chinaberry in front of Dr. Mix's residence	U. S. E.	P	81.572
Marksville Barbin Landing road; Bize's gin, 800 feet north of, root bench on pin oak	U. S. E.	P	77.711
——Bordelon store, in front of, root bench in west side of most northerly chinaberry	U. S. E.	P	81.780

LOCATION	AUTHORITY	CLASS	ELEV'N
AVOYELLES PARISH—*Continued*			
Marksville Barbin Landing road—*Continued*			
———Mrs. Frame's house, in front of, root bench in pin oak	U. S. E.	P	79.324
Moreauville; Rabelais' plantation, copper bolt in chimney of cabin 100 feet south of Bayou des Glaises	U. S. E.	P	61.255
Red Fish P. O.; 1 mile below, root bench in sycamore 165 feet north of cabin occupied by Philip Bankes on William Perkin's Place	U. S. E.	P	49.050
Red River, BARBIN LANDING; pipe-flange bench in corner of yard at residence, 130 feet southwest of warehouse	U. S. E.	P	57.980
——— ———Root bench in cottonwood 165 feet from river and 65 feet west of warehouse	U. S. E.	P	56.992
———BAYOU L'EAU NOIR; 60 feet south of, nail in side of pecan, on south of road 650 feet east of road crossing from Saline Point	U. S. E.	P	51.588
———BETTEVY'S STORE; 100 feet below, root bench on cottonwood, 30 feet from river	U. S. E.	P	57.913
———BROUILLETTE PLACE; upper end of, root bench on sycamore, 500 feet below last cabin on Bettevy's Place, 80 feet from river	U. S. E.	P	56.236
———CHOCTAW BAYOU; root bench in willow on left bank of bayou	U. S. E.	P	63.210
——— ———Root bench in cottonwood 265 feet below bayou and 80 feet from right bank of river	U. S. E.	P	63.483
———DAVID FERRY; copper bolt in chimney at southwest end of Laborde's house	U. S. E.	P	66.353
———EGG BEND LANDING; root bench in locust at foot of levee opposite store	U. S. E.	P	63.156
———JUNCAN PLACE; 250 feet below residence, root bench in cottonwood, 65 feet from right bank of river	U. S. E.	P	57.032
———LABORDE LANDING; 800 feet below, root bench in elm opposite big two story frame house on left bank	U. S. E.	P	60.789
———MURRAY LANDING; Monlards place, root bench on leaning willow 65 feet from bank of Red River; 300 feet above house on Old Raccouri place	U. S. E.	P	52.300
———NORMAND'S LANDING; 0.4 mile above, root bench in sycamore 30 feet from river	U. S. E.	P	59.030
——— ———330 feet above, on Reynands place, root bench in cottonwood 165 feet from river	U. S. E.	P	57.212
———REYNAND'S PLACE; copper bolt in chimney of residence	U. S. E.	P	61.532

LOCATION	AUTHORITY	CLASS	ELEV'N
AVOYELLES PARISH—*Continued*			
Red River—*Continued*			
——SALINE BAYOU; mouth of, high water 1892	U. S. E.	E	56.98
——SALINE POINT; 3250 feet south of, pipe-flange bench in yard at residence of John White	U. S. E.	P	54.472
Simmesport; 1.5 miles west of, copper bolt in chimney of cabin on Atchafalaya road, right bank of Bayou des Glaises, about 575 feet east of Harlands Bayou	U. S. E.	P	50.515
——pipestone bench in J. Trudeau's yard, south of Norwood's store	U. S. E.	P	41.962
Vorhees; grade center of station	L. R. & N.	R	55.4
BIENVILLE PARISH			
Alberta; grade, center of station	L. & A.	R	181.
Arcadia; 2 miles east of, root bench in pine north of track, 325 feet east of mile-post 117	U. S. E.	P	352.543
—— root bench in white oak north of track, 325 feet west of milepost 119	U. S. E.	P	358.877
——pipestone bench in yard of most easterly of 4 section house	U. S. E.	P	368.984
——top of rail, center of station	V. S. & P.	R	361.9
——2 miles west of, root bench 120 feet north of bridge, 325 feet east of milepost 121	U. S. E.	P	338.040
Black Lake Bayou, L. & A. BRIDGE; top of stringer	L. & A.	R	158.
—— ——high water	L. & A.	R	153.
—— ——bed of bayou	L. & A.	R	131.
Camp Long; southeast corner sec. 3, T. 15 N., R. 9 W	S. L. B. & S.	R	288.
Castor; grade, center of station	L. & A.	R	181.
Castor Bayou, L .& A. CROSSING; bed of bayou	L. & A.	R	154.
Davis Station; top of rail, center of platform	S. L. B. & S.	R	287.
Greyburg; grade, center of station	L. & A.	R	257.
Gibsland; 2 miles east of, root bench in white oak south of track and 115 feet west of milepost, 126	U. S. E.	P	229.776
——root bench in hickory, 115 feet north of track and 250 feet west of milepost 128	U. S. E.	P	219.233
——pipestone bench in Colbert Hotel yard 100 feet south of track	U. S. E.	P	241.941
——top of rail center of station	V. S. & P.	R	246.9
Grand Bayou, S. L. B. & S. BRIDGE; Secs. 21–22, T. 15 N., R. 9 W., top of rail	S. L. B. & S.	R	239.
—— ——bed of bayou	S. L. B. & S.	R	228.
—— —— Secs. 27–28, T. 15 N., R. 9 W., top of rail	S. L. B. & S.	R	230.
—— ——bed of bayou	S. L. B. & S.	R	221.
Jamestown; grade, center of station	L. & A.	R	231.

LOCATION	AUTHORITY	CLASS	ELEV'N
BIENVILLE PARISH—*Continued*			
Lawhorn; grade, center of station	L. & A.	R	268.
Martin Junction;	S. L. B. & S.	R	259.
Red River Parish line;	S. L. B. & S.	R	223.
Ringold; top of rail center of station	S. L. B. & S.	R	274.
——1 mile south of, 0.25 mile south of northwest corner of Sec. 10, T. 15 N., R. 9 W., summit between Brushy and Grand Bayous	S L. B. & S.	R	294.
Taylor;	V. S. & P.	R	227.
——pipestone bench in gin yard 58 feet south of track	U. S. E.	P	218 269
Thomas Station;	S. L. B. & S.	R	252.
BOSSIER PARISH			
Alden Bridge; pipestone bench, in hotel yard, 260 feet: west of track, 400 feet northeast of station	U. S. E.	P	215.521
——1.3 miles south of, root bench in post oak east of track, 130 feet south of milepost 433.	U. S. E.	P	212.468
Antrim; root bench in pine, east of track, 80 feet south of milepost 424............	U. S. E.	P	255.732
Arkanna; root bench in red oak, east of track, 1 telegraph pole north of state line..	U. S. E.	P	245.534
Atkins; grade center of station........	L. R. & N.	R	150.7
Benton; 2 miles north of, root bench in post oak, 165 feet south of milepost 435...	U. S. E.	P	213.359
——pipestone bench in northeast corner of section house yard....................	U. S. E.	P	210.067
Bodcan; top of rail center of station.........	V. S. & P.	R	206.1
——pipestone bench in Oliver William's yard, 80 feet south of track..............	U. S. E.	P	203.713
Bolinger; 0.5 mile north of, root bench in white oak east of track, 8 telegraph poles north of milepost 419..........	U. S. E.	P	339.504
Bossier City; pipestone bench in yard of Mrs. M. D. C. Cane......................	U. S. E.	E	170.70
——St. L. S. W. crossing..........	L. R. & N.	R	175.1
—— V. S. & P. bridge "X" on anchor bolt on first pier at east end................	U. S. E.	P	186.250
Brownlee Station; 0.5 mile north of, root bench in elm, 130 feet east of track, 4.5 telegraph poles south of milepost 445..............................	U. S. E.	P	172.314
——0.5 mile south of, root bench in elm, east of track at trestle 90.....	U. S. E.	P	172.889
Chalk Level; grade center of station........	L. R. & W.	R	173.7
Curtis; grade center of station...............	L. R. & N.	R	163.7
Curtis P. O.; 1000 feet south of, root bench in cotton wood, 650 feet east of Red River	U. S. E.	P	166.385
Elm Grove; grade center of station..........	L. R. & N.	R	155.2
Harvey; grade center of station............	L. R. & N.	R	159.7

LOCATION	AUTHORITY	CLASS	ELEV'N
BOSSIER PARISH—*Continued*			
Haughton; top of rail, center of station	V. S. & P.	R	239.9
——pipestone bench in J. T. Edward's yard..	U. S. E.	P	236.759
Hughes; 1.5 miles north of, root bench in post oak, west of track, 2.5 telegraph poles south of milepost 429..............	U. S. E.	P	219.553
Hunter; grade center of station............	L. R. & N.	R	153.7
Ninock; grade, center of station............	L. R. & N.	R	150.7
Plain Dealing; pipestone bench, 325 feet north of depot, 60 feet west of track.	U. S. E.	P	260.415
Poole; grade center of station	L. R. & N.	R	148.7
Red River; Alban's Canal (No. 1); 80 feet from south side of, pipestone bench 450 feet from river....	U. S. E.	E	200.98
——BENOIT BAYOU; 420 feet above, pipestone bench on levee in front of T. J. Vance's house........	U. S. E.	E	181.69
—— ——Do...........................	U. S. E.	P	181.739
——BOONE BEND; at head of, pipestone bench opposite narrow part of neck and 128 feet from river.......	U. S. E.	E	203.60
——CURTIS; high water 1892................	U. S. E.	E	171.12
—— ——1000 feet south of, root bench in cottonwood, 650 feet east of river.......	U. S. E.	P	166.385
——DUTCH JOHN LAKE; pipestone bench between lake and river, 320 feet above Fuller inlet.........	U. S. E.	E	197.30
——GILMER LANDING; 2400 feet above, pipestone bench on top of bluff just below Fuller outlet.......................	U. S. E.	E	237.86
—— ——1000 feet above, pipestone bench at Dr. Vance's residence...............	U. S. E.	E	222.17
——HURRICANE BLUFF; 0.9 mile above mouth of Old river, 80 feet from left bank.............................	U. S. E.	E	191.69
—— ——pipestone bench at residence of Ivory.............................	U. S. E.	P	191.500
—— ——1000 feet above mouth of bayou at, top of boss of standard bench mark pipe, 1650 feet from river............	U. S. E.	P	228.803
——LUSK FERRY; pipestone bench in southwest corner of yard of Jake Lusk, 1300 feet from river....................	U. S. E.	P	229.139
——KINCAID PLACE; pipestone bench in field 165 feet east of bayou and 375 feet back of levee.......................	U. S. E.	P	163.901
——LAKE HOME PLANTATION; pipe stone bench on back levee 150 feet below bend................	U. S. E.	E	189.50
——MILLER'S BLUFF; pipestone bench in southwest corner of yard of Jake Lusk, 1300 feet from river.................	U. S. E.	P	229.139
——NINOCK BAYOU; high water 1892........	U. S. E.	E	149.27
——PANDORA PLANTATION; pipestone bench on levee at: first bend above ferry...	U. S. E.	E	181.16

LOCATION	AUTHORITY	CLASS	ELEV'N
BOSSIER PARISH—*Continued*			
Red River—*Continued*			
——POSTEN BAYOU; 160 feet below, pipestone bench 250 feet from river	U. S. E.	E	198.78
—— ——Do	U. S. E.	P	198.254
——VANCE (COL.) PLANTATION; pipestone bench at intersection of north stable yard fence with public road..........	U. S. E.	E	177.26
——VANCE (T. J.) PLANTATION; See Vanceville.			
Red River Parish line; grade.............	L. R. & N.	R	147.7
Roberta; root bench in red oak west of track, 100 feet south of wagon road crossing.	U. S. E.	P	320.842
Taylortown; grade, center of station	L. R. & N.	R	155.7
Vanceville; 1.8 miles north of, root bench in cotton wood, 650 feet east of track 8 telegraph poles north of milepost 442	U. S. E.	P	178.325
——1 mile north of, X cut on brick chimney below mark "U. S," 200 feet west of track, 3.5 telegraph poles north of milepost 443....................	U. S. E.	P	177.802
—— pipestone bench on levee in front of residence of T. J. Vance................	U. S. E.	P	181.739
——Do	U. S. E.	E	181.69
Wadley Station; top of rail center of station	V. P. & P.	R	189.9
Willow Chute; 0.5 mile north of, root bench in sycamore west of track, 9 telegraph poles north of milepost 439..........	U. S. E.	P	183.673
CADDO PARISH			
Albany Point; pipestone bench in northeast corner of yard	U. S. E.	P	222.868
Ananias; 1.6 miles north of, rail end bench, 45 feet northeast of milepost 533.5......	K. C. S.	P	181.61
——1.1 miles north of, rail end bench, 12 feet west of milepost 534.................	K. C. S.	P	190.72
——0.6 mile north of, rail end bench, 15 feet west of milepost 534.5..	K. C. S.	P	194.73
——0.1 mile north of, rail end bench, 15 feet west of milepost 535	K. C. S.	P	196.42
——0.4 mile south of, rail end bench, 18 feet west of first telegraph pole north of milepost 535.5......................	K. C. S.	P	205.28
——0.9 mile south of, rail end bench, 60 feet north of milepost 536	K. C. S.	P	206.15
Arkansas-Louisiana State line; rail end bench, 9 feet west of milepost 516....	K. C. S.	P	228.80
Beckville; grade, center of station...........	M. K. & T.	R	271.
Black Bayou. K. C. S. R. R. CROSSING; top of rail	K. C. S.	R	203.00
—— ——high water	K. C. S.	R	200.50
—— ——bank of bayou..................	K. C. S.	R	183.
—— —— bed of bayou	K. C. S.	R	174.

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Blanchard; 4 miles north of, rail end bench, 15 feet west of first telegraph pole north of milepost 544	K. C. S.	P	285.33
——3.5 miles north of, rail end bench, 60 feet southwest of second telegraph pole south of milepost 544.5	K. C. S.	P	305.84
——3 miles north of, rail end bench, 60 feet southwest of milepost 545	K. C. S.	P	292.60
——2.5 miles north of, rail end bench, 70 feet feet southwest of milepost 545.5.....	K. C. S.	P	286.57
——2 miles north of, rail end bench, 15 feet northwest of first telegraph pole south of milepost 546....................	K. C. S.	P	283.77
——1.5 miles north of, rail end bench, 12 feet west of milepost 546.5	K. C. S.	P	270.17
——1 mile north of, rail end bench, 12 feet west of milepost 547	K. C. S.	P	244.00
——0.5 mile north of, rail end bench, 10 feet west of milepost 547.5.	K. C. S.	P	226.43
——rail end bench, 12 feet west of milepost 548	K. C. S.	P	227.91
——depot, top of rail, at center...............	K. C. S.	R	227.00
——0.5 mile south of, rail end bench, 30 feet northwest of milepost 548.5..........	K. C. S.	P	223.83
——1 mile south of, rail end bench, 25 feet west of milepost 549................	K. C. S.	P	213.19
——1.5 miles south of, rail end bench, 25 feet northwest of milepost 549.5..........	K. C. S.	P	211.65
——2 miles south of, rail end bench, 20 feet west of milepost 550	K. C. S.	P	203.96
——2.5 miles south of, rail end bench, 40 feet north of first telegraph pole north of milepost 550.5	K. C. S.	P	201.50
——3 miles south of, rail end bench, 30 feet southwest of third telegraph pole south of milepost 551	K. C. S.	P	187.84
——3.5 miles south of, rail end bench, 95 feet south of milepost 551.5	K. C. S.	P	186.36
——4 miles south of, rail end bench, 20 feet southwest of milepost 552	K. C. S.	P	195.15
——4.5 miles south of, rail end bench, 15 feet northwest of milepost 552.5..........	K. C. S.	P	195.86
——5 miles north of, rail end bench, 75 feet north of first telegraph pole north of milepost 553	K. C. S.	P	191.06
——5.5 miles south of, rail end bench, 85 feet north of milepost 553.5	K. C. S.	P	186.56
——6 miles south of, rail end bench, 25 feet northwest of milepost 554	K. C. S.	P	183.68
Boggy Bayou, T. & P. BRIDGE; top of stringer...........................	T. & P.	R	171.4
—— ——bed of bayou...................	T. & P.	R	155.
Brushy Bayou, T. & P. BRIDGE; top of stringer................	T. & P.	R	203.5

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Mooringsport—*Continued*			
——1.8 miles north of, rail end bench, 50 feet southwest of second telegraph pole south of milepost 537.5.............	K. C. S.	P	209.87
——1.3 miles north of, rail end bench, 15 feet west of milepost 538...............	K. C. S.	P	192.73
——0.8 mile north of, rail end bench, 7 feet west of first telegraph pole north of milepost 538.5....................	K. C. S.	P	200.12
——0.3 mile north of, rail end bench, 15 feet west of first telegraph pole south of bridge "B 539"....................	K. C. S.	P	201.32
——pipestone bench on north side of C. S. Croon's store	U. S. E.	P	183.135
——DEPOT, top of rail at center..............	K. C. S.	R	197.00
——0.2 mile south of, bench mark on northeast corner of north pedestal, east pair, water tank..........................	K. C. S.	P	194.33
——0.7 mile south of, rail end bench, 45 feet left of track opposite milepost 540...	K. C. S.	P	206.05
——1.2 miles south of, rail end bench, 20 feet west of first telegraph pole north of milepost 540.5.....................	K. C. S.	P	195.06
——1.7 miles south of, rail end bench, 20 feet west of milepost 541.................	K. C. S.	P	190.87
——2.2 miles south of, rail end bench, 25 feet west of milepost 541.5...............	K. C. S.	P	198.23
——2.7 miles south of, rail end bench, 20 feet west of milepost 542.................	K. C. S.	P	207.53
——3.2 miles south of, rail end bench, 15 feet west of milepost 542.5	K. C. S.	P	238.50
——3.7 miles south of, rail end bench, 15 feet west of milepost 543..................	K. C. S.	P	261.90
——4.2 miles south of, rail end bench, 20 feet southwest of milepost 543.5..........	K. C. S.	P	277.56
Myrtis; 0.8 mile north of, rail end bench, 15 feet north of fifth telegraph pole south of milepost 522..........................	K. C. S.	P	215.86
——0.3 mile north of, rail end bench, 15 feet southwest of second telegraph pole north of milepost 522.5..............	K. C. S.	P	198.12
——platform, top of rail, at south end......	K. C. S.	R	211.
——0.2 mile south of, rail end bench, 10 feet west of milepost 523	K. C. S.	P	207.78
——0.7 mile south of, rail end bench, 15 feet west of milepost 523.5..............	K. C. S.	P	221.64
——1.2 miles south of, rail end bench, 75 feet north of milepost 524................	K. C. S.	P	212.14
——1.7 miles south of, rail end bench, 18 feet west of milepost 524.5...............	K. C. S.	P	227.35
——2.2 miles south of, rail end bench, 17 feet west of milepost 525	K. C. S.	P	234.50
Preston; top of rail, center of station.........	H. & S.	R	270.3

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Red River, ARKANSAS-LOUISIANA STATE LINE; 500 feet above, pipestone bench 30 feet from bluff and 75 feet from bank of bayou	U. S. E.	E	212.04
——ASHWOOD LANDING; root bench in barren mulberry 50 feet below gin on Cash Place	U. S. E.	P	156.305
—— ——pipestone bench 450 feet from river and 270 feet northwest of bayou on Cash plantation	U. S. E.	P	152.286
——BARR'S FERRY; pipestone bench in yard of cabin 400 feet from river	U. S. E.	E	172.60
——BARGETOWN SLOUGH; 90 feet south of, pipestone bench east of levee	U. S. E.	E	204.85
——BEAR POINT; 1950 feet below, root bench in small chinaberry on road, 65 feet from river	U. S. E.	P	151.741
——BEASLEY'S LANDING; pipestone bench at cabin 1000 feet back of store	U. S. E.	E	186.87
——BONNER PLANTATION; pipestone bench near cabin 600 feet from river and 1000 feet southwest of gin	U. S. E.	P	144.013
——CAMPO BELLO PLANTATION high water, 1892	U. S. E.	E	151.80
—— ——pipestone bench in Dr. T. Allison's yard	U. S. E.	P	146.437
——CASPIANA LANDING; pipestone bench on Hutchinson's plantation 8 feet east of gin and 415 feet from river	U. S. E.	P	148.141
——CORNER PLANTATION; pipestone bench, 2500 feet below Cottonwood Bayou at cabin on small slough	U. S. E.	E	182.31
——COTTON POINT STORE; root bench in chinaberry 65 feet south southwest of store and 165 feet northwest from gin	U. S. E.	P	146 983
——DIXON'S STORE; pipestone bench 400 feet back of levee between branches of Cowhide Bayou	U. S. E.	E	189.92
——ERIC (JOHN) PLANTATION; pipestone bench in field below house and 800 feet back of gin	U. S. E.	E	180.64
——GOLD POINT PLANTATION; at southwest corner of, at intersection of lanes and 600 feet from river	U. S. E.	E	178.24
——HERNDON'S (E. B.) PLANTATION; pipestone bench back of cabin, opposite Dr. Dillards and 600 feet from river	U. S. E.	E	174.57
——HERNDON PLANTATION; pipestone bench at cabin nearly opposite line between Cash and Carmouché plantations	U. S. E.	E	174.86
——LOTUS LANDING; highwater 1892	U. S. E.	E	163.18
—— ——pipestone bench in yard of Capt. Robson's store and 150 feet from river	U. S. E.	P	157.639

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Red River—*Continued*			
——MISSIONARY PLACE; upper end of, high water 1892	U. S. E.	E	213.64
——PERU PLANTATION; pipestone bench on levee between plantation and Dooley's Bayou, 300 feet from bayou	U. S. E.	E	195.50
——RUSH POINT; high water 1892	U. S. E.	E	195.27
——SODA FOUNT PLANTATION; pipestone bench on back levee near Carolina plantation line	U. S. E.	E	180.53
——SOUTHSIDE PLANTATION; west side of, pipestone bench on levee along small bayou	U. S. E.	E	176.70
——WILD LUCIA; high water 1892	U. S. E.	E	199.01
Rhodessa; 3 miles north of, rail end bench, 15 feet west of milepost 516.5	K. C. S.	P	218.46
——2.5 miles north of, rail end bench, 20 feet west of milepost 517	K. C. S.	P	211.04
——2 miles north of, rail end bench, 65 feet north of first telegraph pole north of milepost 517.5	K. C. S.	P	201.02
——1.5 miles north of, rail end bench, 15 feet west of milepost 518	K. C. S.	P	208.11
——1 mile north of, rail end bench, 20 feet west of milepost 518.5	K. C. S.	P	206.60
——0.5 mile north of, rail end bench, 15 feet west of milepost 519	K. C. S.	P	230.18
——rail end bench at second telegraph pole north of milepost 519.5	K. C. S.	P	226.91
——depot, at center, top of rail	K. C. S.	R	329.
——0.5 mile south of, rail end bench, 12 feet west of fourth telegraph pole north of milepost 520	K. C. S.	P	213.78
——1.5 miles south of, rail end bench, 7 feet west of milepost 521	K. C. S.	P	211.87
——2 miles south of, rail end bench, 12 feet west of first telegraph pole north of milepost 521.5	K. C. S.	P	214.67
Robson; pipestone bench in yard of Capt. Robson's store 150 feet from river	U. S. E.	P	157.639
——high water 1892	U. S. E.	E	163.18
Reisor; grade, center of station	T. & P.	R	190.4
Shreveport; 4 miles north of, rail end bench, 15 feet west of milepost 555	K. C. S.	P	163.41
——3.5 miles north of, rail end bench, 60 feet north of third telegraph pole south of milepost 555.5	K. C. S.	P	185.78
——3 miles north of, rail end bench, 45 feet left of track opposite milepost 556	K. C. S.	P	189.79
——2.5 miles north of, rail end bench, 85 feet north of third telegraph pole south of milepost 556.5	K. C. S.	P	208.34

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Shreveport—*Continued*			
——2 miles north of, rail end bench, 20 feet southeast of second telegraph pole south of milepost 557..................	K. C. S.	P	230.43
——1.5 miles north of, bench mark on 0.75 inch rod 1 foot west of west side of round house....................	K. C. S.	P	249.124
——rail end bench, 15 feet west of first telegraph pole north of South head block of Y..............................	K. C. S.	P	219.51
——rail end bench, 25 feet northwest of third telegraph pole south of milepost 559.	K. C. S.	P	206.63
—— pipestone bench in yard of Post Office....	U. S. E.	P	*a*195.744
——high water, 1892	U. S. E.	E	176.70
—— zero, U. S. E. gauge.....................	U. S. E.	E	140.99
——V. S. & P. BRIDGE; west end, top of rail	V. S. & P.	R	189.3
——"X" on lower course of top stones on south side of west abutment V. S. & P. bridge	U. S. E.	P	181.800
——highest point in, Hicks Street east of Fairfield street.....................	*b*	L	276.
——CROSSING OF T. & P	H. & S.	R	228.
—— M. K. & T. CROSSING; top of rail	K. C. S.	R	238.9
——T. & P. CROSSING; top of rail...........	K. C. S.	R	238.3
——H. & S. freight station, top of rail, center of	H. & S.	R	234.
——H. & S. crossing, grade	K. C. S.	R	234.
——bench mark on southwest corner stone of sill door, men's waiting room at Union Depot.............................	K. C. S.	P	208.61
——bench mark on southwest corner of brick foundation on first bent, south end of coal chute track....	K. C. S.	P	247.55
——bench mark on corner curb, north side of Jordon Street, 20 feet right of track	K. C. S.	P	243.86
——junction, pipe under oak 68 feet right of track.........	T. & P.	R	230.28
——0.5 mile south of, rail end bench, 12 feet west of milepost 559.5	K. C. S.	P	202.64
——1 mile south of, rail end bench 75 feet north of milepost 560	K. C. S.	P	203.02
——1.5 miles south of, rail end bench, 25 feet northwest of milepost 560.5..........	K. C. S.	P	214.88
——2 miles south of, rail end bench, 12 feet west of milepost 561	K. C. S.	P	225.01
——2.5 miles south of, rail end bench, 25 feet west of milepost 561.5..............	K. C. S.	P	210.52
——3 miles south of, rail end bench, 25 feet northwest of first telegraph pole north of milepost 562..................	K. C. S.	P	219.04
—— 3.5 miles south of, rail end bench, 25 feet west of milepost 562.5..............	K. C. S.	P	206.17

a Elevation by line Camden to Shreveport 195.585 feet.
b Map of Shreveport showing sewer pipe system, Nov., 1900.

LOCATION	AUTHORITY	CLASS	ELEV'N
CADDO PARISH—*Continued*			
Shreveport—*Continued*			
——4 miles south of, rail end bench, 25 feet west of milepost 563	K. C. S.	P	203.30
——4.5 miles south of, rail end bench, 25 feet northwest of milepost 563.5	K. C. S.	P	202.67
Sodo Lake; lower end of, right bank, pipestone bench at Albany Point in northeast corner of yard	U. S. E.	P	222.868
——upper end of, right bank, pipestone bench near northwest corner of deserted house at Henderson Mills	U. S. E.	P	244.352
Texas-Louisiana line;	M. K. & T.	R	261.
Twelve Mile Bayou; head of, right bank, pipestone bench at Albany Point in northeast corner of yard	U. S. E.	P	222.868
Vivian; 1.2 miles north of, rail end bench, 20 feet northwest of milepost 525.5	K. C. S.	P	224.35
——0.7 mile north of, rail end bench, 12 feet west of milepost 526	K. C. S.	P	250.91
——0.2 mile north of, rail end bench, 65 feet south of first telegraph pole north of milepost 526.5	K. C. S.	P	246.28
——depot, at center, top of rail	K. C. S.	R	250.8
——0.3 mile south of, rail end bench, 12 feet west of milepost 527	K. C. S.	P	251.36
——0.8 mile south of, rail end bench, 8 feet west of milepost 527.5	K. C. S.	P	245.95
——1.3 miles south of, rail end bench, 10 feet southwest of second telegraph pole north of milepost 528	K. C. S.	P	247.10
——1.8 miles south of, rail end bench, 15 feet west of second telegraph pole north of milepost 528.5	K. C. S.	P	226.47
——2.3 miles south of, rail end bench, 20 feet west of milepost 529	K. C. S.	P	215.93
——2.8 miles south of, rail end bench, 20 feet west of second telegraph pole north of milepost 529.5	K. C. S.	P	206.29
——3.3 miles south of, rail end bench, 45 feet north of milepost 530	K. C. S.	P	206.63
CALDWELL PARISH			
Banks Spring; grade at water tank	St.L.I.M.& S.	R	184.0
Bayou Crew; 500 feet west of a bridge on north side of Columbia—Three Rivers road, root bench on pin oak	U. S. E.	P	59.117
Bayou Lafourche; 550 feet northeast of bridge on, east side of Boeuf River—Columbia road, root bench on Spanish oak	U. S. E.	P	66.143
Black Bayou, St. L. I. M. & S. CROSSING; grade	St.L.I.M.& S.	R	118.4

LOCATION	AUTHORITY	CLASS	ELEV'N
CALDWELL PARISH—*Continued*			
Blanktown; pipestone bench in J. A. Davis' yard	U. S. E.	P	64.252
Boeuf River P. O.; 0.5 mile above, root bench in pin oak, east side of Boeuf River—Landerneau road	U. S. E.	P	63.101
Boeuf River, BIG CREEK; pipe-flange bench opposite mouth of	U. S. E.	E	54.33
——BIRD LAKE LANDING; 1000 feet above, pipe-flange bench on Harris place, 130 feet from river	U. S. E.	P	65.020
——BRANDIN (LEOPOLD) PLACE; root bench in pin oak, 15 feet from river, 500 feet northwest of residence	U. S. E.	P	64.150
——BRANDIN (PAUL) PLACE; pipe-flange bench at old Doucier Landing	U. S. E.	P	65.113
——DUFF PLACE; pipe-flange bench on river bank 200 feet from Duff's cabin	U. S. E.	E	61.30
——HARRIS PLACE; pipe-flange bench 130 feet from river, 1000 feet above Bird Lake Landing	U. S. E.	P	65.020
——HERBERTS; zero of gage, 1898	U. S. E.	E	20.12
——HERBERT'S LANDING; pipe-flange bench in garden back of house of widow Johnson	U. S. E.	P	62.502
——THREE RIVERS FERRY; pipe-flange bench 250 feet above Columbia-Winnsboro road	U. S. E.	P	54.415
Columbia; pipestone bench at corner of Wall and Main streets	U. S. E.	P	61.341
——station, grade, north head block	St.L.I.M.&S.	R	126.8
——station, grade, south head block	St L.I.M.&S.	R	134.8
——low water 1873	U. S. E.	E	20.44
——high water 1882	U. S. E.	E	69.78
——1.5 miles below, pipe-flange bench on the I. Davis place, on the left bank	U. S. E.	P	68.325
——opposite, root bench in water oak, 90 feet from river bank, 250 feet northwest of ferry landing	U. S. E.	P	64.003
Columbia—Three Rivers road; north side of, root bench in pin oak, 500 feet west of bridge over Bayou Crew	U. S. E.	P	59.117
Grayson; grade, center of station	St.L.I.M.&S.	R	159.0
Hurricane Creek, ST. L. I. M. & S. CROSSING; bridge	St.L I.M.&S.	R	127.1
—— ——high water	St.L.I.M.&S.	R	122.7
—— ——bank	St.L.I.M.&S.	R	121.
—— ——bed of creek	St.L.I.M.&S.	R	110.
Kelly; grade, center of station	St.L.I.M.&S.	R	120.4
Landerneau; root bench in water oak in front of gin	U. S. E.	P	63.580
——high water 1882	U. S. E.	E	70.24
——low water 1899	U. S. E.	E	38.18
——zero of gage	U. S. E.	E	20.44

LOCATION	AUTHORITY	CLASS	ELEV'N
CALDWELL PARISH—*Continued*			
Ouachita River, BELLEVUE LANDING; root bench in pecan 311 feet north of landing	U. S. E.	P	65.268
——BIG LAKE; root bench in white oak, 65 feet west of lake, 425 feet south of Indian mound	U. S. E.	P	62.253
——COLES LANDING; pipestone bench in southwest corner of V. Thompson's field, 50 feet east of Wade Bayou	U. S. E.	P	60.567
——COTTINGHAM LANDING; pipestone bench on top of ridge, and 72 feet west of road	U. S. E.	P	57.860
——DAVIS (I.) PLACE; pipe-flange bench near south boundary, 690 feet from east boundary	U. S. E.	P	68.325
——DANVILLE; top of gas pipe in northwest corner of horse lot adjoining Baughman's residence	U. S. E.	P	60.219
—— ——root bench in pecan, 200 feet from river and 65 feet south of Bayou Dan.	U. S. E.	P	58.368
—— ——high water 1882	U. S. E.	E	69.58
——GIBSON LANDING; pipe-flange bench in J. W. Price's yard	U. S. E.	P	61.253
——HENRIETTE LANDING; 2625 feet from, root bench in elm, on south side Harrisonburg road	U. S. E.	P	59.653
——JACK'S LANDING; 250 feet southeast of, boat spike in sweet gum, 130 feet from river	U. S. E.	P	65.652
——LONG LAKE LANDING; root bench in red oak, 50 feet east of left river bank	U. S. E.	P	61.336
——MYER (C. C.) PLACE; root bench in pin oak, 20 feet west of west fence and 65 feet east of road	U. S. E.	P	60.094
——PETERS BAYOU; root bench in sweet gum on north bank, 980 feet above mouth	U. S. E.	P	56.510
——ST. L. I. M. & S. BRIDGE; grade	St.L.I.M.&S.	R	81.1
—— ——chisel mark in upper edge of lowest piece of sheet iron casing of northwest pier	U. S. E.	P	56.261
——SINOPE LANDING; root bench on catalpa in front of house	U. S. E.	P	73.124
—— ——high water 1882	U. S. E.	E	70.50
—— ——pipe-flange bench southeast of Filhiol residence, 450 feet from left bank of river	U. S. E.	E	69.75
——UPPER BRESTON LANDING; pipe-flange bench in first lane south of residence, 425 feet from river	U. S. E.	E	68.99
——WACO LANDING; 0.6 mile above, pipe-flange bench at lane end, 200 feet from Methodist Church	U. S. E.	E	74.77
——WADE PLACE; pipe-flange bench 500 feet below steam gin	U. S. E.	P	66.353

LOCATION	AUTHORITY	CLASS	ELEV'N
CALDWELL PARISH—*Continued*			
Riverton; grade, center of station	St.L.I.M.&S.	R	68.1
——zero of gage	U. S. E.	E	14.92
——325feet southeast of station, root bench on sweet gum 30 feet from track.	U. S. E.	P	67.312
——1 mile south of, root bench in mulberry 800 feet from north end of trestle approach to drawbridge	U. S. E.	P	66.722
——1 mile south of, pipestone bench, 1000 feet from north end of trestle approach to drawbridge	U. S. E.	P	63.141
Smith Lake; 820 feet from end of trestle approach to drawbridge over Ouachita River	U. S. E.	P	66.722
Three Rivers Ferry; pipe-flange bench on Boeuf River 250 feet above Columbia-Winnsboro road	U. S. E.	P	54.415
CATAHOULA PARISH			
Black River, BOATNER PLANTATION; root bench in oak, 50 feet east of levee, and 650 feet northeast of residence	U. S. E.	P	54.745
—— ——root bench in oak, on road 25 feet east of levee; 500 feet from river, and 3250 feet below store	U. S. E.	P	55.834
——JONES BAYOU; pipe-flange bench on south side of bayou on Nicholia place	U. S. E.	P	58.923
——MAYS LANDING; 325 feet southwest from root bench in pecan, 50 feet west of levee	U. S. E.	P	55.953
——MONTGOMERY LANDING; pipe-flange on south side of road 1200 feet from river.	U. S. E.	E	53.64
——SECURITY; high water 1882	U. S. E.	E	61.41
——SECURITY P. O.; root bench in cotton wood, 600 feet south of store and 50 feet west of river	U. S. E.	P	57.402
——TRISLER LANDING; 2000 feet below, pipe-flange bench on mound west of Fair-play place	U. S. E.	E	57.80
——WHITEHEAD'S (John and Gabe) GIN; root bench in persimmon 800 feet north of gin and 65 feet west of river	U. S. E.	P	56.343
Boeuf River, ALLIGATOR LANDING; 1.4 miles above pipe-flange bench on right bank 6 miles above mouth	U. S. E.	E	49.14
Chickasaw Creek, ST. L. I. M. & S. TRESTLE; grade	St.L.I.M.&S.	R	85.0
Chisum Station; pipe-flange bench on Newman plantation road 100 feet west of track	U. S. E.	P	71.739
Copeland; pipe-flange bench 115 feet east of track, and 115 feet southeast of station	U. S. E.	P	64.058

LOCATION	AUTHORITY	CLASS	ELEV'N
CATAHOULA PARISH—*Continued*			
Copeland—*Continued*			
——2 miles west of, root bench in elm, east of track, 5 telegraph poles north of milepost 26	U. S. E.	P	53.664
Florence Station; pipe-flange bench 400 feet north of depot and 50 feet west of track..........	U. S. E.	P	72.373
——1.4 miles north of, pipe-flange bench at Chisum, south side of road, 100 feet west of track	U. S. E.	P	71.739
Funne Louis Creek, L. & A. CROSSING; bed of creek.........................	L. & A.	R	74.
Harrisonburg; a V mark on brick at ground level on northeast corner of clerk's office in Court House yard...	U. S. E.	P	67.378
——copper bolt in second brick from southwest corner of Parish jail............	U. S. E.	P	79.077
——high water 1882......................	U. S. E.	E	65.68
Jena; grade, center of station...............	L. & A.	R	156.
——1.5 miles west of, divide between Trout and Hemphill Creeks near milepost 185	L. & A.	R	211.
Jonesville; high water 1882....	U. S. E.	E	62.73
——pipestone bench in Dr. Baker's lot	U. S. E.	P	54.018
Kirks Ferry; see under Tensas River.			
Little River, ST. L. I. M. & S. CROSSING; bridge	St.L.I.M.&S.	R	87.3
—— ——high water......................	St.L.I M.&S.	R	86.3
—— ——north bank..........	St.L.I.M.&S.	R	56.
—— ——bed of river....	St.L.I.M.&S.	R	27.
—— L. & A. CROSSING; bed of river.........	L. & A.	R	24.
Olla; grade, center of station	St.L.I.M.&S.	R	153.6
Ouachita River, BUSHLEY BAYOU; 130 feet north of, root bench in live oak, 100 feet southeast of Hugh's dwelling....	U. S. E.	P	59.800
—— ——650 feet south of mouth, pipe-flange bench at wood line, 1050 feet from right bank of river	U. S. E.	E	59.12
——CATAHOULA SHOALS; pipestone bench in pine grove 40 feet from west bank of river	U. S. E.	P	57.194
—— ——high water 1890.......	U. S. E.	E	62.82
——DAVIS LANDING; pipe-flange bench on upper edge of old Davis place, 550 feet from right bank of river ..	U. S. E.	E	58.79
——GILLESPIE PLACE; root bench in pecan 235 feet northwest of river and 115 feet southwest of Mrs. Calvert's residence................	U. S. E.	P	58.004
——PETER'S BAYOU; 2300 feet below, pipe-flange bench on left bank of river...	U. S. E.	E	62.79
——STAFFORD; pipestone bench, 230 feet west of river and opposite mouth of Boeuf River	U. S. E.	P	56.367

LOCATION	AUTHORITY	CLASS	ELEN'N
CATAHOULA PARISH—*Continued*			
Ouachita River—*Continued*			
—— ——high water 1882	U. S. E.	E	66.79
—— ——zero of gage	U. S. E.	E	—20.28
——TEW LAKE OUTLET; pipe-flange bench 1650 feet from right bank of river and 165 feet south of wood line	U. S. E.	E	57.48
——TRINITY; .25 mile above, pipe-flange bench on upper side of Gillespie place, 800 feet from right bank of river	U. S. E.	E	57.44
Peck; pipe-flange bench in corner of cotton field, about 80 feet from station seed house	U. S. E.	P	74.793
——2.4 miles south of, pipe-flange bench on Newman property 30 feet east of trestle on north bank of bayou	U. S. E.	P	71.403
——1 mile south of, root bench in pin oak, east of track and 820 feet south of milepost 33	U. S. E.	P	73.213
Searcy; grade, center of station	L. & A.	R	121.
——3 miles east of, grade near milepost 183	L. & A.	R	202.
Security; see under Black River.			
Sicily Island P. O.; see Florence Station.			
Stafford; see under Ouachita River.			
Tensas River, ANCHOR PLACE; root bench in oak on east side of road	U. S. E.	P	60.927
——GREENVILLE; pipe-flange bench 265 feet from N. O. and N. W. R. R. track and 113 feet west of main right bank	U. S. E.	P	64.484
——KIRK'S FERRY; pipe-flange bench in yard of S. F. Kiper, above mouth of Choctaw Bayou	U. S. E.	P	64.957
—— ——zero of gage	U. S. E.	E	—17.06
—— ——high water 1897	U. S. E.	E	63.77
——LEE BAYOU; pipe-flange bench on bank, 165 feet west of track	U. S. E.	P	63.392
Trinity; pipestone bench on Guss estate, back of kitchen	U. S. E.	P	53.624
——high water 1882	U. S. E.	E	62.86
——low water 1873	U. S. E.	E	8.26
Tullos; grade, center of station	St.L.I.M.&S.	R	106.1
Urania; grade, center of station	St.L.I.M.&S.	R	91.0
CONCORDIA PARISH			
Acme P. O.; see under Black River			
Black Hawk; see under Mississippi River			
Black River, ACME; pipe-flange bench in field on J. A. Lanius' place, 630 feet from Black River	U. S. E.	E	52.10
—— ——pipe-flange bench 75 feet northeast of river and 265 feet below Burleigh's Landing	U. S. E.	P	50.224
——ALTON LANDING; 950 feet below, pipe-flange bench 40 feet from river	U. S. E.	E	55.18

LOCATION	AUTHORITY	CLASS	ELEV'N
CONCORDIA PARISH—*Continued*			
Black River—*Continued*			
——BARKER LANDING; 2000 feet south of, root bench in ironwood on levee, 650 feet south of bayou..................	U. S. E.	P	53.381
——CALHOUN LANDING; see Eva P. O.			
——CYNTHIA BAYOU; root bench in ironwood on levee 650 feet south of Bayou.....	U. S. E.	P	53.381
——DELHOSTE LANDING; pipe-flange bench 100 feet from river and 225 feet from landing..............................	U. S. E.	P	48.984
——EMMERSON LANDING; pipe-flange bench 75 feet south of river and 125 feet northeast of residence	U. S. E.	P	51.995
——EVA P. O.; pipe-flange bench 30 feet west of bank of Black river, and 200 feet north of N. Calhoun's residence	U. S. E.	P	53.590
——GILLESPIE'S BAYOU; 1300 feet above, pipe-flange bench in Jackson's field, 13 feet from bank	U. S. E.	E	52.32
——HARDSCRAMBLE LANDING; pipe-flange bench 20 feet south of road and 60 feet south of levee	U. S. E.	P	54.242
——LANIUS (J. A.) PLACE; 0.6 mile above Acme P. O., pipe-flange bench in field, 650 feet from river..................	U. S. E.	E	52.10
——LUMS LANDING; pipe-flange bench 50 feet southeast of Pauhl's residence and 500 feet north of river.................	U. S. E.	P	52.284
——MONTEREY; 0.5 mile below, pipe-flange bench on line between T. 5 and 6 N..	U. S. E.	E	54.19
—— ——mouth of, high water 1882........	U. S. E.	E	57.97
—— ——mouth of, high water 1892........	U. S. E.	E	56.39
—— ——mouth of, zero of gage	U. S. E.	E	— 20.51
——PLOUDEN'S BAYOU; 560 feet north of, pipe-flange bench on line of T. 5 and 6 N., R. 7 E.......................	U. S. E.	E	54.19
Black River Station; zero of gage..........	U. S. E.	E	4.49
——high water 1893......	U. S. E.	E	59.28
——pipestone bench opposite mouth of Little River, 200 feet from depot......... ..	U. S. E.	P	51.198
——root bench in hackberry, 225 feet from main bank of Ouachita River, and near high water section of gage......	U. S. E.	P	55.097
——root bench in pignut hickory near U. S. gage	U. S. E.	P	48.741
——root bench in sweet gum near U. S. gage.	U. S. E.	P	50.571
——7 miles east of, root bench on pecan, south of N. R. R. and T. R. R. track, 80 feet southeast of milepost 7..........	U. S. E.	P	57.377
Bougere; see under Mississippi River.			
Clayton; see under Tensas River.			
Concordia; pipe-flange bench, 16 feet south of N. R. R. and T. R. R. track at station	U. S. E.	P	60.329

LOCATION	AUTHORITY	CLASS	ELEV'N

CONCORDIA PARISH—*Continued.*

LOCATION	AUTHORITY	CLASS	ELEV'N
Cypress; pipe-flange bench in yard of Henry Elerbee (colored) 275 feet west of N. O. & N. W. R. R. track	U. S. E.	P	58.243
Eva P. O.; see under Black River.			
Frogmore; pipestone bench in southwest corner of section house yard	U. S. E.	P	56.442
Helena; pipe-flange bench 65 feet from track in lane on property of Graves Veaton Co.	U. S. E.	P	60.396
Mississippi River, ASHLEY PLANTATION; granite post	U.S.C.&G.S.	P	54.088
——BLACK HAWK; 3 miles south of, on Ballamagan Plantation, near engine house, cut in cistern marked "U. S. B. M. [] LII"	U.S.C.&G.S.	P	56.409
—— ——granite post at east steps of E. Pullen's residence	U.S.C.&G.S.	P	52.265
——BOUGÈRE; Ashland Plantation, granite post at steps of W. G. Walton's residence	U.S.C.&G.S.	P	56.959
——BULLITS BAYOU PLANTATION; marble post at right of entrance of residence next plantation store	U.S.C.&G.S.	P	64.378
——DEER PARK PLANTATION; marble post at steps of agent's house	U.S.C.&G.S.	P	59.152
——FAIRVIEW, BRABSTON PLANTATION; marble posts at steps of residence	U.S.C.&G.S.	P	56.150
——GIBSONS LANDING; marble post at northwest corner of Stanton and Brandon's store	U.S.C.&G.S.	P	65.967
——LUMS POINT; copper bolt in stone post on Lums Plantation opposite Fort Adams, Miss	U.S.C.&G.S.	P	53.010
—— ——POINT BREEZE PLANTATION; copper bolt in stone post	U.S.C.&G.S.	P	53.142
——MORO PLANTATION; marble post near steps of owner's dwelling	U.S.C.&G.S.	P	64.129
—— ——0.5 mile below the above granite post	U.S.C.&G.S.	P	63.098
——MORVILLE LANDING; 2 miles below, on Ashley Plantation, granite post	U.S.C.&G.S.	P	54.088
—— ——1 mile above, on Moro Plantation, granite post	U.S.C.&G.S.	P	63.098
Monterey; see under Black River.			
New Era; pipe-flange bench, 75 feet south of river and 125 feet northeast of residence at Emerson Landing	U. S. E.	P	51.995
Otta Bayou, N. R. R. & T. R. R. CROSSING; pipestone bench on east bank, 35 feet north of track, 35 feet east of trestle.	U. S. E.	P	56.442
Red River, BLACK RIVER; 500 feet below mouth of, cement filled, vitrified pipe in Delhoste's field	U. S. E.	E	47.40

LOCATION	AUTHORITY	CLASS	ELEV'N
CONCORDIA PARISH—*Continued.*			
Stanton Station; east of, pipe-flange bench near cotton platform on Athlone place	U. S. E.	E	55.88
Tensas River, ATHLONE PLACE; high water 1893	U. S. E.	E	60.63
——ATHLONE PLACE; pipe-flange bench near cotton platform east of Stanton station	U. S. E.	E	55.88
——CLAYTON; pipe-flange bench, 82 feet northeast of track of N. O. & N. W. R. R., and 30 feet southeast of river	U. S. E.	P	61.337
—— ——zero of gage	U. S. E.	E	17.06
—— ——high water 1893	U. S. E.	E	63.77
——low water	U. S. E.	E	20.70
——HAPHAZARD; high water, 1893	U. S. E.	E	61.25
——LAMARQUE PLACE; high water 1893	U. S. E.	E	62.63
Vidalia; 4.5 miles above, marble post in levee, near old brick wall	U.S.C.&G.S.	P	68.256
—— marble post at steps of Judge W. H. Hough's residence	U.S.C.&G.S.	P	63.276
——Do	U. S. E.	P	63.422
——Bolt in granite monument in lot behind courthouse and jail (*a*)	U.S.C.&C.S.	P	61.089
——Do(*b*)	U. S. E.	P	61.235
DE SOTO PARISH			
Benson; 3.6 miles north of, rail end bench 15 feet west of milepost 600.5	K. C. S.	P	304.24
——2.6 miles north of, rail end bench 108 feet west of milepost 601.5	K. C. S.	P	276.22
—— 2.1 miles north of, rail end bench 40 feet north of first telegraph pole south of milepost 602	K. C. S.	P	280.09
——1.6 miles north of, rail end bench 15 feet west of milepost 602.5	K. C. S.	P	268.52
——1.1 miles north of, rail end bench 15 feet southwest of milepost 603	K. C. S.	P	252.94
——0.6 mile north cf, rail end bench 35 feet southwest of third telegraph pole south of milepost 603.5	K. C. S.	P	248.12
——0.1 mile north of. rail end bench 12 feet southwest of milepost 604	K. C. S.	P	249.29
——0.4 mile south of, rail end bench 8 feet west of milepost 604.5	K. C. S.	P	241.70
——0.9 mile south of, rail end bench 10 feet west of milepost 605	K. C. S.	P	231.03
——1.4 miles south of, rail end bench, 35 feet southwest of first telegraph pole north of milepost 605.5	K. C. S.	P	229.37
Billmore; top of rail, center of station	H. & S.	R	312.5
Caddo Parish line; top of stringer Keatchie Bayou bridge	H. & S.	R	239.
Cypress Bayou, T. & P. BRIDGE; top of stringer north end	T. & P.	R	176.5
—— ——bed of bayou	T. & P.	R	161.

(*a*) "Bench found disturbed in 1893."
(*b*) In 1893.

LOCATION	AUTHORTY	CLASS	ELEV'N
De Soto Parish—*Continued.*			
De Soto Parish line; rail end bench 35 feet southwest of first telegraph pole north of milepost 605.5	K. C. S.	P	229.37
Franks; top of rail, center of station	H. & S.	R	330.6
Frierson; 4.2 miles north of rail end bench 15 feet west of first telegraph pole south of milepost 572	K. C. S.	P	166.63
——3.7 miles north of, rail end bench 20 feet west of milepost 572.5	K. C. S.	P	183.56
——3.2 miles north of, rail end bench, 45 feet right of first telegraph pole north of milepost 573	K. C. S.	P	203.38
——2.7 miles north of, rail end bench 35 feet southwest of first telegraph pole west of milepost 573.5	K. C. S.	P	208.52
——2.2 miles north of, rail end bench 20 feet west of milepost 574	K. C. S.	P	227.56
——1.7 miles north of, rail end bench 20 feet southwest of third telegraph pole south of milepost 574.5	K. C. S.	P	212.86
——1.2 miles north of, rail end bench, 15 feet west of milepost 575	K. C. S.	P	201.59
——0.7 mile north of, rail end bench, 15 feet west of milepost 575.5	K. C. S.	P	190.95
——0.2 mile north of, rail end bench, 55 feet south of milepost 576	K. C. S.	P	185.88
——0.3 miles south of, rail end bench, west of milepost 576.5	K. C. S.	P	187.61
——0.8 mile south of, rail end bench, 15 feet west of milepost 577	K. C. S.	P	177.17
——1.3 miles south of, spike in milepost 577.5	K. C. S.	P	164.17
——1.8 miles south of, rail end bench 18 feet west of milepost 578	K. C. S.	P	174.26
——2.3 miles south of, rail end bench, 20 feet west of milepost 578.5	K. C. S.	P	164.04
——2.8 miles south of, rail end bench, 18 feet west southwest of sixth telegraph pole south of milepost 579	K. C. S.	P	165.07
——3.3 miles south of, rail bench, 18 feet northwest of milepost 479.5	K. C. S.	P	179.43
Funston; top of rail, center of station	H. & S.	R	231.7
Gloster; grade, center of station	T. & P.	R	250.1
Grand Cane; grade, center of station	T. & P.	R	301.5
Hollingsworth Station; rail end bench, 15 feet west of first telegraph pole north of milepost 588	K. C. S.	P	251.17
Holly; 3.2 miles north of, rail end bench, 15 feet northwest of milepost 581	K. C. S.	P	195.00
——2.7 miles north of, rail end bench, 50 feet southwest of first telegraph pole south of milepost 581.5	K. C. S.	P	178.09
——2.2 miles north of, rail end bench, 15 feet west of milepost 582	K. C. S.	P	168.54

LOCATION	AUTHORITY	CLASS	ELEV'N
DE SOTO PARISH—*Continued*			
Holly—*Continued*			
——1.7 miles north of, rail end bench 60 feet south of milepost 582.5	K. C. S.	P	206.44
——1.2 miles north of, rail end bench, 10 feet west of sixth telegraph pole south of milepost 583........................	K. C. S.	P	231.51
——0.7 mile north of, rail end bench 10 feet west of first telegraph pole north of milepost 583.5........	K. C. S.	P	217.93
——0.2 mile north of, rail end bench, 15 feet west of first telegraph pole north of milepost 584....	K. C. S.	P	196.97
——0.3 mile south of, rail end bench, 90 feet south of milepost 584.5	K. C. S.	P	185.84
——0.8 mile south of, rail end bench, 35 feet northwest of milepost 585..........	K. C. S.	P	178.01
——1.3 miles south of, rail end bench, 15 feet southwest of milepost 585.5..........	K. C. S.	P	193.95
——1.8 miles south of, rail end bench 30 feet north of second telegraph pole north of milepost 586	K. C. S.	P	195.65
——2.3 miles south of, rail end bench, 35 feet southwest of milepost 586.5..........	K. C. S.	P	178.16
——2.8 miles south of, 20 feet southwest of first telegraph pole north of milepost 587.	K. C. S.	P	198.96
Keatchie; top of rail, center of station	H. & S.	R	338.4
Kingston; 0.1 mile north of, rail end bench, 40 feet north of milepost 580........	K. C. S.	P	201.16
——0.4 mile south of, rail end bench, 75 feet south of milepost 580.5..............	K. C. S.	P	216.58
Lupton; top of rail, center of station........	H. & S.	R	253.2
Logansport; top of rail, center of station....	H. & S.	R	207.4
Mansfield; 3.7 miles north of, rail end bench, 95 feet north of milepost 587.5.......	K. C. S.	P	224.83
——3.2 miles north of, rail end bench, 15 feet west of first telegraph pole north of milepost 588...............	K. C. S.	P	251.17
——2.7 miles north of, rail end bench, 20 feet northwest of third telegraph pole south of milepost 588.5..............	K. C. S.	P	281.33
——2.2 miles north of, rail end bench, 15 feet northwest of second telegraph pole south of milepost 589................	K. C. S.	P	302.80
——1.7 miles north of, rail end bench, 60 feet south of first telegraph pole south of milepost 589.5	K. C. S.	P	299.75
——1.2 miles north of, rail end bench 90 feet north of second telegraph pole north of milepost 590	K. C. S.	P	311.83
——0.7 mile north of, rail end bench 15 feet west of milepost 590.5..............	K. C. S.	P	324.69
——0.2 mile north of, rail end bench 20 feet west of milepost 591................	K. C. S.	P	339.28

LOCATION	AUTHORITY	CLASS	ELEV'N
De Soto Parish—*Continued*			
Mansfield—*Continued*			
——0.8 mile south of, rail end bench 85 feet north of first telegraph pole north of milepost 592	K. C. S.	P	332.02
——1.3 miles south of, rail end bench 15 feet west of milepost 592.5	K. C. S.	P	351.31
——1.8 miles south of, rail end bench 15 feet west of third telegraph pole south of milepost 593	K. C. S.	P	351.16
——2.3 miles south of, rail end bench 85 feet north of milepost 593.5	K. C. S.	P	343.06
——2.8 miles south of, rail end bench 75 feet south of first telegraph pole south of milepost 594	K. C. S.	P	356.22
——3.3 miles south of, rail end bench 20 feet southwest of second telegraph pole north of milepost 594.5	K. C. S.	P	364.26
——3.8 miles south of, rail end bench 18 feet west of first telegraph pole south of milepost 595	K. C. S.	P	351.70
Mansfield Junction; 0.5 mile north of, rail end bench 15 feet west of third telegraph pole south of milepost 593	K. C. S.	P	351.16
——grade, center of station	T. & P.	R	316.0
——T. & P. Crossing; top of rail	K. C. S.	R	343.7
—— ——rail end bench 85 feet north of milepost 573.5	K. C. S.	P	343.06
——0.5 mile south of, rail end bench 75 feet south of first telegraph pole south of milepost 594	K. C. S.	P	356.22
Odin; top of rail, center of station	H. & S.	R	274.0
Oxford; grade, center of station	T. & P.	R	257.5
Pelican; grade, center of station	T. & P.	R	315.5
Sabine Parish Line; rail end bench 35 feet southwest of first telegraph pole north of milepost 605.5	K. C. S.	P	229.37
Stonewall; grade, center of station	T. & P.	R	211.8
Trenton; 2.5 miles north of, rail end bench, 15 feet west of second telegraph pole north of milepost 595.5	K. C. S.	P	358.46
——2 miles north of, rail end bench 12 feet west of third telegraph pole south of milepost 596	K. C. S.	P	353.71
——1.5 miles north of, rail end bench, 15 feet west of first telegraph pole south of milepost 596.5	K. C. S.	P	346.81
——1 mile north of, rail end bench, 18 feet south of milepost 597	K. C. S.	P	359.21
——bench mark on northwest corner, north pedestal of west pair water tank	K. C. S.	P	347.78
——rail end bench, 12 feet west of milepost 598	K. C. S.	P	341.02
——0.5 mile south of, rail end bench, 60 feet north of milepost 598.5	K. C. S.	P	346 05

LOCATION	AUTHORITY	CLASS	ELEV'N
DE SOTO PARISH—*Continued*			
Trenton—*Continued*			
———1 mile south of, rail end bench, 50 feet south of fourth telegraph pole south of milepost 599	K. C. S.	P	315.42
———1.5 miles south of, rail end bench 75 feet north of milepost 599.5	K. C. S.	P	314.92
———2 miles south of, rail end bench 18 feet west of second telegraph pole south of milepost 600	K. C. S.	P	309.07
Wallace Lake; rail end bench 40 feet south of first telegraph pole south of lake	K. C. S.	P	163.69
EAST CARROLL PARISH			
Henderson; copper bolt in pillar of dwelling owned by Mrs. Emma E. Peck	U.S.C. & G.S.	P	101.819
———copper bolt in chimney of cabin opposite old gin	U.S.C. & G.S.	P	99.168
Lake Providence; zero, U. S. E. gage	U. S. E.	E	69.34
FRANKLIN PARISH			
Baskin Station; pipe-flange bench opposite north end of platform	U. S. E.	P	73.752
Bayou Macon, CUT-OFF BAYOU; at mouth of, pipe-flange bench on knoll west of warehouse	U. S. E.	E	68.43
——— ———above, zero of gauge	U. S. E.	E	—20.61
———CUT-OFF LANDING; high water 1893	U. S. E.	E	67.88
———JACKSON'S LANDING; pipe-flange bench in Tom Griffin's barn lot	U. S. E.	P	87.042
——— ———root bench on right bank of Pullaway Bayou, 65 feet from Bayou Maçon	U. S. E.	P	73.658
———OSBORNE FERRY; pipe-flange bench in northeast corner of yard of W. R. Osborne	U. S. E.	P	78.181
———OSBORNE LANDING; high water 1882	U. S. E.	E	76.80
——— ———high water 1893	U. S. E.	E	71.75
———PULLAWAY BAYOU; root bench in right bank 65 feet from Bayou Maçon	U. S. E.	P	73.658
———PULLAWAY LANDING; see Bayou Maçon, Jackson Landing.			
———SUNSHINE LANDING; pipe-flange bench in lot adjoining J. L. Newcomer's residence	U. S. E.	P	91.878
———WARSAW LANDING; root bench in red oak, 165 feet below large warehouse.	U. S. E.	P	84.605
Big Creek, N. O. & N. W. R. R. CROSSING; pipe-flange bench 225 feet east of bank, 80 feet south of track	U. S. E.	P	74.391
Big Creek Station; 1 mile south of, root bench on post oak east of track, 4.5 telegraph poles south of milepost 60	U. S. E.	P	74.279
Boeuf River, DALY LANDING; pipe-flange bench, 50 feet northeast of warehouse	U. S. E.	E	66.30

LOCATION	AUTHORITY	CLASS	ELEV'N
FRANKLIN PARISH—*Continued*			
Boeuf River—*Continued*			
——DE SHA LANDING; pipe-flange bench, 40 feet from river on Smith place.......	U. S. E.	E	64.37
——GUM POINT LANDING; pipe-flange bench 32 feet north of warehouse...........	U. S. E.	E	60.33
——MASON'S LANDING; zero of gage 1899...	U. S. E.	E	— 20.44
Como, NEW LIGHTS ROAD, ROARING BAYOU; 500 feet west of, root bench in white oak on south side of road............	U. S. E.	P	58.329
Delhi, WARSAW ROAD, DOVER; 350 feet south of, root bench in red elm	U. S. E.	P	87.154
——JACKSON LANDING; near, pipe-flange bench in Tom Griffin's barn lot	U. S. E.	P	87.042
Eden Station; pipe-flange bench, 30 feet east of track, 260 feet north of platform..	U. S. E.	P	71.667
Elam; pipe-flange bench at Mrs. L. Allen's store, 100 feet west of track..........	U. S. E.	P	72.210
Gilbert; pipe-flange bench in southwest corner of garden of Ephraim Williams, 500 feet southwest of depot..........	U. S. E.	P	77.748
Lamar P. O.; 742 feet south of, root bench in white oak west side of Warsaw road.	U. S. E.	P	88.492
Osborne's Ferry; see under Bayou Maçon.			
Peck; 1 mile north of, root bench in thorn, west of track and two telegraph poles north of milepost 35................	U. S. E.	P	58.404
Steele Switch; pipe-flange bench 50 feet east of track, 130 feet south of trestle....	U. S. E.	P	72.238
Warsaw-Delhi Road; see Delhi-Warsaw Road.			
Winnsboro; 1 mile north of, root bench on white oak 1.5 telegraph poles south of milepost 53........................	U. S. E.	P	70.812
——pipe-flange bench in lot of Mrs. Adams opposite depot.....................	U. S. E.	P	72.142
Wisner; pipe-flange bench, 65 feet east of track, 650 feet south of depot	U. S. E.	P	74.745
——1 mile south of, root bench on hickory east of track nine telegraph poles south of milepost 37.................	U. S. E.	P	73.068
GRANT PARISH			
Antonia Station; grade, center of depot.....	St.L.I.M.&S.	R	189.0
——1 mile north of, summit of grade, near milepost 615......................	St.L.I.M.&S.	R	195.4
Bayou d' Artigo, L. R. & N. BRIDGE; Sec. 22, T. 8 N., R. 4 W., top of stringer.....	L. R. & N.	R	119.
—— ——bed of bayou.....................	L. R. & N.	R	110.
—— ——Secs. 10-15, T. 8 N., R. 4 W., root bench on beech north of bayou west of track..........................	L. R. & N.	R	134.3
Bayou de Gaup, L. R. & N. BRIDGE; north of, root bench on pin oak west of track.	L. R. & N.	R	89.2
—— ——top of stringer...................	L. R. & N.	R	94.

LOCATION	AUTHORITY	CLASS	ELEV'N
GRANT PARISH—*Continued*			
Bayou Marteau, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	90.9
——— ———bed of bayou	L. R. & N.	R	61.
Bayou Nantaches, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	102.2
Bayou Patessa, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	87.9
Big Creek, ST. L. I. M. & S. BRIDGE; south end	St.L.I.M.&S.	R	95.2
——— ———high water	St.L.I.M.&S.	R	93.2
——— ———bed of creek	St.L.I.M.&S.	R	82.2
Boggy Bayou, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	101.6
——— ——— high water 1892	L. R. & N.	R	93.7
Colfax; grade, center of station	L. R. & N.	R	96.
———pipestone bench in courthouse yard	U. S. E.	P	96.183
———high water 1892	U. S. E.	E	95.73
Cornfield Bayou, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	98.
——— ———bed of bayou	L. R. & N.	R	85.
Fairmount P. O.; 1.25 miles above, pipestone bench on Mrs. A. C. Deal's plantation, opposite Deloache's Rock	U. S. E.	P	94.552
Finley's Spur; grade, center of station	St.L.I.M.&S.	R	172.3
Fish Creek, St. L. I. M. & S. BRIDGE; north end	St.L.I.M.&S.	R	84.8
Georgetown; grade St. L. I. M. & S. crossing	L. & A.	R	94.
——— grade, center of station	St.L.I.M.&S.	R	97.4
Howcott Station; grade, center of station	St.L.I.M.&S.	R	85.6
———1 mile north of, grade at milepost 607	St.L.I.M.&S.	R	96.6
Kitchens Creek, ST. L. I. M. & S. BRIDGE; top of stringer	St.L.I.M.&S.	R	152.5
——— ———bed of creek	St.L.I.M.&S.	R	137.5
Little River, ST. L. I. M. & S. CROSSING; grade of bridge	St.L.I.M.&S.	R	87.3
——— ——— high water	St.L.I.M.&S.	R	86.3
——— ———south bank	St.L.I.M.&S.	R	70.
——— ———bed of river	St.L.I.M.&S.	R	27.
——— L. & A. CROSSING; bed of river	L. & A.	R	24.
Montgomery; grade, center of station	L. R. & N.	R	152.7
———high water 1892	U. S. E.	E	101.37
Nugent Station; 2 miles north of, summit of grade near milepost 625	St.L.I.M.&S.	R	206.3
———grade, center of station	St.L.I.M.&S.	R	171.4
Pollock; grade, center of depot	St.L.I.M.&S	R	96.2
Rapides Parish line; grade. L. R. & N. track	L. R. & N.	R	89.
Rochelle; grade, center of station	St.L.I.M.&S.	R	81.
Sand Spur; see Antonia Station.			
Red River, DUNN LANDING; 1200 feet above, pipestone bench near cabin on Dunn plantation	U. S. E.	P	104.749

LOCATION	AUTHORITY	CLASS	ELEV'N
GRANT PARISH—*Continued*			
Red River—*Continued*			
——FAIRMOUNT; 1.25 miles above, pipestone bench on plantation of Mrs. Deal, opposite Deloache's Rock	U. S. E.	P	94.552
Sandy Creek, St. L. I. M. & S. BRIDGE; top of stringer	St.L.I.M.&S.	R	152.3
Winn Parish line; grade L. R. & N. track	L. R. & N.	R	164.
Verde Station; grade, center of station	L. R. & N.	R	165.0
——400 feet south of, root bench on red oak east of track	L. R. & N.	R	161.14
JACKSON PARISH			
Allendale;	A. S.	R	177.
Ansley Station;	A. S.	R	191.
Bridge Creek, A. S. BRIDGE; Sec. 8, T. 16 N., R. 3 W., top of rail	A. S.	R	182.3
—— ——bed of creek	A. S.	R	172.
Clay P. O.; top of rail at Elmore Station	A. S.	R	206.3
Cypress Creek, A. S. BRIDGE, Sec. 31, T. 16 N, R. 3 W, top of rail	A. S.	R	162.
—— ——bank of creek	A. S.	R	157.
—— ——bed of creek	A. S.	R	147.
Elmore Station; top of rail, center of station	A. S.	R	206.3
Hodge; top of rail, center of station	A. S.	R	191.
Jonesboro; top of rail, center of station	A. S.	R	212.
——2 miles south of at milepost 23	A. S.	R	246.
Lincoln Parish Line; top of rail, A. S. R. R.	A. S.	R	211.
Parsons Creek, A. S. BRIDGE; Sec. 18, T. 16 N., R. 3 W., top of rail north end of bridge	A. S.	R	181.
Winn Parish line; top of rail, A. S. R. R.	A. S.	R	170.
Wyatt; top of rail, north head block	A. S.	R	191.
LINCOLN PARISH			
Allengreen; top of rail, center of station	V. S. & P.	R	330.
——pipestone bench 165 feet northwest of station and 150 feet north of track	U. S. E.	P	330.169
Alexton; near, top of big cut	A. S.	R	231.
Averitt; top of rail, center of station	V. S. & P.	R	156.
Choudrant; top of rail, center of station	V. S. & P.	R	154.9
——pipestone bench, 215 feet north of track at southeast corner of Farmer's Union office	U. S. E.	P	152.279
——2 miles west of, root bench in white oak 65 feet north of bridge 215, and 650 feet west of milepost 97	U. S. E.	P	152.090
Dubach; top of rail, center of station	A. S.	R	135.
Jackson Parish line; top of rail, A. S. R. R.	A. S.	R	211.
Ruston; 1.5 miles east of, root bench in large pine north of track and 100 feet west of milepost 101	U. S. E.	P	249.635
——top of rail V. S. & P. crossing	A. S.	R	304.5
——pipestone bench in courthouse yard at corner of Louisiana and Vienna streets	U. S. E.	P	314.460

LOCATION	AUTHORITY	CLASS	ELEV'N
LINCOLN PARISH—*Continued*			
Ruston—*Continued*			
——top of rail, center of station............	V. S. & P.	R	311.9
——1.5 miles west of, rail end bench south of track and 650 feet from milepost 104.	U. S. E.	P	241.181
Tremont; 2 miles east of, root bench in large pine south of track and 1315 feet west of milepost 89................	U. S. E.	P	178.501
Simmsboro; top of rail, center of station....	V. S. & P.	R	325.9
——pipestone bench in yard of Mr. Madden..	U. S. E.	P	320.312
MADISON PARISH			
Bayou Macon, ANDREW FERRY; 0.6 mile below, root bench in pin oak 288 feet below cabin on Montgomery place...	U. S. E.	P	73.894
——ANDREW'S FIELD; root bench in pin oak, north side of lane, .4 mile south of bayou..........................	U. S. E.	P	76.362
——MONTGOMERY PLACE; see Bayou Maçon Andrews Ferry.			
Barnes; top of rail center of station..........	V. S. & P.	R	88.3
——pipestone bench in yard of cabin opposite store	U. S. E.	P	81.030
California Station; pipestone bench in yard or Mrs. N. Thomas.................	U. S. E.	P	88.217
——top of rail, center of station...	V. S. & P.	R	95.3
Dallas; top of rail, center of station.........	V. S. & P.	R	87.
——zero of Tensas river gage........... ...	U. S. E.	E	54.10
——pipestone bench about 7 feet east of cabin just west of Tensas river on north side of track	U. S. E.	P	76.206
Delta; top of rail, center of station.........	V. S. & P.	R	93.2
——copper bolt in stone post south of V. S. & P. R. R. and east of main street.....	U. S. E.	P	87.453
——Do....................................	U.S.C. & G.S.	P	87.495
Duckport; see under Mississippi river.			
Eldorado; top of rail, center of station	V. S. & P.	R	87.8
Kellogg's Landing; see under Mississippi river			
Lake One Station; top of rail, center of station	V. S. & P.	R	90.
——pipestone bench northwest of Waddell's sawmill, 187 feet northeast of east pier of V. S & P. bridge...	U. S. E.	P	77.301
Lums; top of rail, center of station..........	V. S. & P.	R	91.4
Millikens Bend; see under Mississippi River.			
Mississippi River, CABIN TEELE PLANTATION; copper bolt in northeast pillar of dwelling	U.S.C.&G.S.	P	98.641
——CRYSTAL SPRING PLANTATION; copper bolt in east chimney of dwelling . .	U.S.C.&G.S.	P	87.619
——DUCK PORT PLANTATION; copper bolt in third pillar from northeast corner of dwelling porch....	U.S.C.&G S.	P	97.202
——ECHO PLANTATION; copper bolt in chimney of dwelling....................	U.S.C.&G.S.	P	97.665

LOCATION	AUTHORITY	CLASS	ELEV'N
MADISON PARISH—*Continued*			
Mississippi River—*Continued*			
——KELLOGS LANDING; copper bolt in southeast chimney of Post Office building.	U.S.C.&G.S.	P	88.267
——MILLIKENS BEND; 0.75 mile above, copper bolt in third brick from northeast corner of foundation of H. P. Morancy's house......	U.S.C.&G.S.	P	97.514
——OMEGA P. O.; 0.25 mile above, Ditchley plantation, copper bolt in chimney of Mrs. Sarah A. Nutt's dwelling.......	U.S.C.&G.S.	P	96.549
——POINT PLACE PLANTATION; copper bolt in second pillar from southeast corner of dwelling.........................	U.S.C.&G.S.	P	90.901
——RIVERVIEW PLANTATION; copper bolt in northeast pillar of dwelling porch....	U.S.C.&G.S.	P	94.394
——SARGENTS POINT; copper bolt in cement block near cabin 2000 feet from river.	U.S.C.&G.S.	P	85.694
——WILLOW GLEN PLANTATION; copper bolt in second pillar from southeast corner of dwelling house porch	U.S.C.&G.S.	P	91.061
Mound station; pipestone bench at northeast corner of most easternly section house of V. S. & P. R R..................	U. S. E.	P	83.138
——top of rail, center of station............ .	V. S. & P.	R	91.1
Omega; see under Mississippi River.			
Quebec; top of rail, center of station.	V. S. & P.	R	87.8
——pipestone bench at store 200 feet southeast of railroad bridge over Bayou Dispute.	U. S. E.	P	75.072
——near, on east bank of Tensas River, 30 feet south of track	U. S. E.	P	78.131
Tallulah; top of rail, center of station........	V. S. & P.	R	90.9
——copper bolt 1.5 feet above floor of gallery, 1.75 feet west of main door of courthouse............................	U. S. E.	P	91.802
Tendal; top of rail, center of station..	V. S. & P.	R	87.8
Tensas River, GRAY PLACE; pipe-flange bench in yard of house occupied by James McPherson	U. S. E.	P	75.264
——JACKS BAYOU; zero of gage	U. S. E.	E	42.81
——QUEBEC PLACE; high water 1893	U. S. E.	E	83.16
——V. S. & P. R. R. BRIDGE; high water 1893	U. S. E.	E	79.69
Waverly; pipestone bench in yard of section foreman	U. S. E.	P	78.532
——top of rail, center of station....	V. S. & P.	R	87.8
MOREHOUSE PARISH			
Arkansas-Louisiana State line; top of rail N. O. & N. W. R.R..........	N.O.&N.W.	R	90.
Bayou Bartholomew, ARKANSAS-LOUISIANA STATE LINE; 1650 feet south of, pipe-flange bench 260 feet east of bayou and 50 feet east of railroad..	U. S. E.	P	107.075

LOCATION	AUTHORITY	CLASS	ELEV'N
MOREHOUSE PARISH—*Continued*			
Bayou Bartholomew—*Continued*			
——BONNER PLACE; pipe-flange bench in yard of cabin on lower end of place.......	U. S. E.	P	91.780
——BONNER FERRY; pipe-flange bench on right top bank of bayou 20 feet from road to ferry........................	U. S. E.	E	94.68
——DAVIS PLACE; root bench in oak on bayou side of road 1150 feet below Pecan Landing..........	U. S. E.	P	94.838
——HUGHES FORD; pipe-flange bench 95 feet from bank at angle where road leaves bayou and goes up lake............	U. S. E.	E	109.31
——JONES PLACE; pipe-flange bench in yard around second cabin from residence, 65 feet north of bayou	U. S. E.	P	86.641
—— ——pipe-flange bench 65 feet east of lane to Williams place and 50 feet south of bayou	U. S. E.	P	90.227
——LINDGROVE LANDING; pipe-flange bench in west corner of field where road from Bonita comes to bayou.........	U. S. E.	P	105.634
——LINDGROVE; zero of gage.......... ...	U. S. E.	E	75.00
——MYERS PLACE; pipe-flange bench, 65 feet south of bayou at end of lane leading to Marble Place.......	U. S. E.	P	90.703
——N. O & N. W. BRIDGE; top of rail.... .	N.O.&N.W.	R	97.
—— ——bed of bayou........	N.O.&N.W.	R	66.
——PECAN LANDING; 1150 feet below residence, root bench in oak on bayou side of road on Davis Place....	U. S. E.	P	94.838
——PRATT PLACE; zero of gage	U. S. E.	E	68.24
——SANDIDGE PLACE; zero of gage.........	U. S. E.	E	53.63
—— ——pipe-flange bench in southwest corner of field, 30 feet north of bayou..	U. S. E.	P	89.114
——WARDS FERRY; pipe-flange bench 10 feet northeast of bridge across drain and 30 feet north of bayou.................	U. S. E.	P	97.096
——WARD PLACE; pipe-flange bench in southwest corner of field near second cabin below residence......	U. S. E.	P	95.703
——WELLS PLACE; pipe-flange bench in northwest corner of field east of first cabin east of residence, 30 feet south of bayou	U. S. E.	P	99.914
Bastrop; 15 5 miles north of, grade Shiloh (Charlon) creek bridge.............	N.O.&N.W.	R	75.
——12.5 miles north of, summit between White Oak creek and Shiloh (Charlon) creek...........................	N.O.&N.W.	R	113.
——11.5 miles north of, grade White Oak creek bridge................	N.O.&N.W.	R	100.
——4 miles north of, summit between Horse Bayou and Bayou Bartholomew......	N.O.&N.W.	R	125.
——top of rail, center of station...........	N.O.&N.W.	R	140.

LOCATION	AUTHORITY	CLASS	ELEV'N
MOREHOUSE PARISH—*Continued*			
Boeuf River; top of rail, N. O. & N.W. bridge	N.O.&N.W.	R	80.
Bonita; 3 miles north of, root bench in white oak east of track and 700 feet south of first cattle gap south of milepost 497..	U. S. E.	P	101.393
——2 miles north of, root bench in elm east of track between third and fourth telegraph poles above milepost 498......	U. S. E.	P	100.806
——pipe-flange bench northeast of corner of section house garden......	U. S. E.	P	106.308
Charlon (Shiloh) Creek; N. O. & N. W. bridge............................	N.O. & N.W.	R	75.
Collinston; 2.5 miles north of, summit of grade Bastrop Hills, track.......	N.O. & N.W.	R	145
——2.5 miles north of, summit of grade Bastrop Hills, top of cut....................	N.O. & N.W.	R	155.
——top of rail, center of station.............	N.O. & N.W.	R	79.5
Doss;....................................	St.L.I.M.&S.	R	77. (a)
Horse Bayou, N. O. & N. W. BRIDGE; north end..............................	N.O. & N.W.	R	91.
—— ——bed of, bayou..................	N.O. & N.W.	R	85.
Jones Station; pipe-flange bench in corner of field opposite station platform and 65 feet south of milepost 496...........	U. S. E.	P	106.709
Lindgrove; see under Bayou Bartholomew.			
Mer Rouge;..	St.L.I.M.&S.	R	93. (a)
Oak Ridge; top of rail, center of station.....	N.O. & N.W.	R	87.5
Parkville; pipestone bench in Bob Tucker's yard 130 feet from Bayou Bartholomew, 650 feet above mouth..........	U. S. E.	P	77.259
Tinsey Bayou; see Charlon Creek.			
White Oak Creek, N. O. & N. W. BRIDGE; top of rail..........................	N.O. & N.W.	R	100.
NATCHITOCHES PARISH			
Antoine Creek, L. & A. R. R. BRIDGE; bed of creek...........................	L. & A.	R	178.
Ashland; grade, center of station............	L. & A.	R	238.
Bayou Pierre, T. & P. R. R BRIDGE; grade, north end............................	T. & P.	R	125.
—— ——bed of bayou.....................	T. & P.	R	75.
Black Lake; high water 1902................	L. R. & N.	L	107.
——lowest point of bed, Sec. 11, T. 11 N., R. 7 W............	L. R. & N.	L	87.
Chestnut; L. & N. W. R. R. crossing, grade	L. & A.	R	261.
Chopin; grade, center of station.............	T. & P.	R	99.8
Clarence; top of rail, center of station.......	L. R. & N.	R	114.7
Campti; top of rail, center of station.........	L. R. & N.	R	124.7
——1 mile north of, northwest quarter of northeast quarter Sec. 29, T. 11 N. R. 7 W., root bench on oak at fork of roads.........................	L. R. & N.	L	171.
Cypress; grade, center of station......	T. & P.	R	100.2

(a) From U. S. Geol. Survey, Bull. No. 160. Not corrected.

LOCATION	AUTHORITY	CLASS	ELEV'N
NATCHITOCHES PARISH—*Continued*			
Derry; grade, center of station	T. & P.	R	105.
Goldonna; grade, center of station	L. & A.	R	141.
Grappes Bluff; top of rail, center of station	L. R. & N.	R	153.7
Hyams; grade, center of station	T. & P.	R	116.
Irma; grade, center of station	L. R. & N.	R	112.7
Luella; grade, center of station	L. R. & N.	R	111.2
Marthaville; grade, center of station	T. & P.	R	253.4
Montgomery; 1 mile below, pipestone bench in yard on Dr. R. E. Jackson's plantation	U. S. E.	P	99.182
Montrose			100.
——4 miles south of, summit of grade, northeast quarter of sec. 6, T. 6 N., R. 6 W.	O. R. & K.	R	235.
——5 miles south of, summit of grade, southwest quarter of sec. 12, T. 6 N., R. 7 W	O. R. & K.	R	326.
—— 10 miles south of, sec. 35, T. 6 N., R. 7 W.	O. R. & K.	R	280.
Natchitoches; grade, center of station	T. & P.	R	118.
North Cypress Creek, L. & A. R. R. BRIDGE; sec. 9, T. 13 N., R. 7 W., top of stringer	L. & A.	R	189.
Piney Creek, L. & A. R. R. BRIDGE; sec. 24, T. 13 N., R. 7 W., north end top of stringer	L. & A.	R	198.
—— ——bed of bayou	L. & A.	R	180.
Provincal; grade, center of station	T. & P.	R	166.1
Red River, BOYCE PLANTATION; just below, pipestone bench near house of George Johnson (colored)	U. S. E.	P	121.162
——BUXTONS LANDING; pipestone bench on J. A. Williams plantation, east of house, 250 feet below mouth of Little River	U. S. E.	P	92.242
——GALLION'S (H. P.) YARD; pipestone bench on east bank of Fausse river opposite lower end of Tiger island	U. S. E.	P	112.795
——Jackson's, R. E., plantation, 1 mile below Montgomery, pipestone bench in yard	U. S. E.	P	99.182
——TIGER ISLAND; opposite lower end, pipestone bench in H. P. Gallion's yard	U. S. E.	P	112.795
——WILLIAM'S (J. A.), PLANTATION; pipestone bench east of house	U. S. E.	P	92.242
——WILLOW; high water 1892	U. S. E.	E	114.13
Red River Parish Line; ground level L. R. & N. R. R	L. R. & N.	R	164.
——grade L. R. & N. R. R	L. R. & N.	R	157.7
Robeline; grade, center of station	T. & P.	R	147.0
Saline Bayou, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	116.2
——L. & A. BRIDGE; stringer	L. & A.	R	120.
—— ——bank of bayou	L. & A.	R	112.
—— ——bed of bayou	L. & A.	R	93.

LOCATION	AUTHORITY	CLASS	ELEV'N
NATCHITOCHES PARISH—*Continued*			
South Cypress Creek, L. & A. BRIDGE; sec. 10, T. 13 N., R. 7 W., top of stringer, north end	L. & A.	R	192.
—— —— bed of creek	L. & A.	R	181.
Victoria; grade, center of station	T. & P.	R	196.
OUACHITA PARISH			
Calhoun; 2 miles east of, root bench in gum, south of track, 1000 feet west of milepost 84	U. S. E.	P	151.750
——pipestone bench in C. C. Harris' yard, 150 feet south of track	U. S. E.	P	165.500
——top of rail, center of station	V. S. & P.	R	164.8
Cheniere; top of rail, center of station	V. S. & P.	R	98.9
——pipestone bench at corner of section house	U. S. E.	P	89.606
Cuba P. O.; see under Ouachita River.			
Forksville; top of rail, center of station	V. S. & P.	R	150.
Gordon Station; pipestone bench in yard of "L" shaped cabin on Whitehead's plantation	U. S. E.	P	64.321
Logtown; high water, Ouachita River, 1871	U. S. E.	E	74.1
——pipestone bench in south corner of R. M. Filhiol's field, 10 feet west of warehouse	U. S. E.	P	71.077
Monroe; top of rail, center of station	V. S. & P.	R	89.4
——pipestone bench in northwest corner of court-house yard	U. S. E.	P	78.025
——pipestone bench in grass plot south of round house at V. S. & P. shops	U. S. E.	P	71.527
——zero of gage Ouachita River	U. S. E.	E	31.10
——high water, Ouachita River, 1882	U. S. E.	E	80.77
——low water, Ouachita River, 1894	U. S. E.	E	32.05
——low water, Ouachita River, 1899	U. S. E.	E	31.10
——2 miles west of, root bench in hickory north of track and 32 feet east of milepost 74	U. S. E.	P	78.121
Ouachita River, BAYOU BARTHOLOMEW; 3940 feet below mouth of, root bench in walnut, 650 feet above storehouse	U. S. E.	P	88.590
——BAYOU D' ARBONNE; mouth of, pipe-flange bench 1100 feet from river and 170 feet from right bank of bayou	U. S. E.	P	74.96
—— BAYOU DE SIARD; 325 feet below mouth of, pipe-stone bench on Indian mound	U. S. E.	P	103.314
——BAYOU LAPINE; 0.4 mile below, pipe-flange bench at west end of lane forming north boundary of Refugio Place.	U. S. E.	E	77.03
——BRIGHT OAK PLACE; root bench in gum 25 feet south of road and 325 feet below dwelling	U. S. E.	P	74.356
——BURNHAM LANDING; 0.75 mile below, pipe-flange bench near northern boundary of Terry place, 325 feet from left bank of river	U. S. E.	E	78.73

LOCATION	AUTHORITY	CLASS	ELEV'N
OUACHITA PARISH—*Continued*			
Ouachita River—*Continued*			
——CHENIERE CREEK; 1 mile above, pipe-flange bench in yard of cabin at end of last lane across "Thirteen mile bend"	U. S. E.	E	77.98
——CUBA P. O.; pipe-flange bench, 28 feet from southeast corner of post-office building	U. S. E.	E	72.27
——CHAFF PLANTATION; root bench in sycamore 82 feet in front of residence	U. S. E.	P	79.897
——GLENDORA PLACE; pipe-stone bench on division line between Young and Glendora Places, 1500 feet from river	U. S. E.	P	81.093
——PARGOUD PLACE; pipestone bench on Indian mound, 325 feet below mouth of Bayou de Siard and 300 feet east of river	U. S. E.	P	103.314
——ROCK ROW SHOALS; pipestone bench on Mrs. Seal's place 130 feet north of left bank of river 330 feet west from Lonewa place fence	U. S. E.	P	76.576
——SMITH (BANK) PLACE; pipestone bench 200 feet east of river and 165 feet northeast of old cabin	U. S. E.	P	78.968
——ZEPH LAKE; root bench in white oak on road 250 feet from southeast corner of lake and 500 feet from river at right of bend	U. S. E.	P	73.622
West Monroe; pipestone bench at southwest corner of Cotton and Natchitoches streets	U. S. E.	P	75.568
——arrow cross in granite capstone of west pier of V. S. & P. bridge over Ouachita river	U. S. E.	P	80.893
Whited; top of rail, center of station	V. S. & P.	R	75.5
RAPIDES PARISH			
Alexandria, ST. L. I. M. & S. BRIDGE; high water 1892	U. S. E.	E	83.36
—— ——high water 1892	U. S. E.	E	82.41
——L. R. & N. BRIDGE; grade	L. R. & N.	R	94.9
——grade, center of station	T. & P.	R	76.6
——K. C. W. & G. R. R. CROSSING	L. R. & N.	R	75.8
——T. & P. CROSSING	St. L.I.M.&S.	E	79.3
——pipestone bench in court house yard	U. S. E.	P	73.690
——pipestone bench in yard of Rapides Parish jail	U. S. E.	P	70.910 (a)
Balls Spur; grade at milepost 629	St.L.I.M.&S.	R	145.5
Bayou Boeuf, SEC. 11, T. 3 N., R. 11 W.; bank	A. & W.	L	85.
—— ——hills just west of	A. & W.	L	130.
Bayou Latanier, L. R. & N. BRIDGE; grade	L. R. & N.	R	68.7

(a) Not now available.

LOCATION	AUTHORITY	CLASS	ELEV'N
RAPIDES PARISH—*Continued*			
Bayou Rigolets, L. R. & N. BRIDGE; grade..	L. R. & N.	R	88.1
——— ———bed of bayou........................	L. R. & N.	R	48.
Boyce; grade, center of station...............	T. & P.	R	88.9
———pipestone bench on right, at first angle in lane running southwest from warehouse..............................	U. S. E.	P	85.846
———high water, Red River 1892..............	U. S. E.	E	88.48
Calcasieu River, SEC. 17, T. 2 N., R. 4 W.; bed of river..............................	A. & W.	L	145.
——— ——— bottom land..........................	A. & W.	L	165.
Cheneyville; grade, center of station........	T. & P.	R	63.7
Cypress Bayou (Bayou Comrade), SEC. 10, T. 2 N., R., 4 W.; bank.............	A. & W.	L	160.
Flaceon Bayou, ST. L. I. M. & S. BRIDGE; grade..................................	St.L.I.M.&S.	R	130.6
——— ———high water, 1886..................	St.L.I.M.&S.	R	127.6
Forest Hill;................................	K.C.W&G.	R	170.
Glenmore;...................................	K.C.W.&G.	R	138.
Grant Parish line; grade L. R. & N. R. R..	L. R. & N.	R	89.
Gravel Hill; Sec. 19, T. 3 N., R. 2 W........	A. & W.	L	190.
Lamourie; grade, center of station...........	T. & P.	R	68.9
Latanier; grade, center of station............	L. R. & N.	R	68.7
Lecompte; grade, center of station..........	T. & P.	R	75.4
Lena; grade, center of station...............	T. & P.	R	113.8
Levin Station; grade at milepost 630........	St.L.I.M.&S.	R	148.6
Magda; grade, center of station.............	L. R. & N.	R	62.2
Moreland; grade, center of station..........	T. & P.	R	78.9
Pineville; west of, St. L. I. M. & S. crossing.	L. R. & N.	R	103.8
Poland; see under Red River.			
Rapides; grade, center of station............	T. & P.	R	86.6
———1 mile below, pipestone bench at intersection of levee and Marye and Cruikshanks division line.................	U. S. E.	P	78.442
Red River, BOYCE; pipestone bench on right, at first angle in lane running southwest from warehouse.....................	U. S. E.	P	85.846
———CANNON'S WOOD YARD; opposite pipestone bench on C. O. Harris' plantation, 105 feet west of levee..........	U. S. E.	P	72.481
———GRAND BEND; pipestone bench on Peart's plantation, midway of neck on thicket side of fence.........................	U. S. E.	P	71.078
———GRIMES BLUFF; high water 1892........	U. S. E.	E	70.89
———HARRIS (C. O.,) PLANTATION; pipestone bench opposite Cannon's Woodyard 105 feet west of levee................	U. S. E.	P	72.481
———JONES QUARTER LANDING; 1000 feet below, pipestone bench 30 feet south of parish road and 40 feet from levee...	U. S. E.	P	66.293
———NEW POLAND; high water 1892..........	U. S. E.	E	72.60
———NORMAND LANDING; high water 1892.	U. S. E.	E	59.38
———ONCE MORE LANDING; high water 1892..	U. S. E.	E	70.07
——— ———pipestone bench in George Wilson's horse lot..........................	U. S. E.	P	60.846

LOCATION	AUTHORITY	CLASS	ELEV'N
RAPIDES PARISH—*Continued*			
Red River—*Continued*			
——Pearts plantation; see Grand Bend.			
——POLAND P. O.; 2 miles below, at Once More Landing, pipestone bench in George Wilson's horse lot..........	U. S. E.	P	60.846
——RAPIDES P. O.; 1 mile below, pipestone bench at intersection of levee and Marye and Cruikshanks division line.	U. S. E.	P	78.442
——ROGERS LANDING; root bench in pecan on road 30 feet inside of levee and 225 feet from dwelling	U. S. E.	P	70.406
——ST. L. I. M. & S. BRIDGE; grade........	St.L.I.M.&S.	R	95.4
—— ——high water 1892................	U. S. E.	E	83.3
Rocky Bayou, L. R. & N. BRIDGE; grade....	L. R. & N.	R	95.1
—— ——bed of bayou	L. R. & N.	R	71.
Spring Creek; Sec. 6, T. 2 N., R. 3 W	A. & W.	L	200.
Tioga; grade at milepost 630...............	St.L.I.M.&S.	R	148.6
Willow Glen; grade, center of station........	T. & P.	R	80.4
Woodsworth....	K.C.W.&G.	R	88.
RED RIVER PARISH			
Bienville Parish line; grade, S. L. B. & S. R. R............................	S.L.B.&S.	R	223.
Bossier Parish line; grade, L. R. & N. R.R.	L. R. & N.	R	147.7
Carroll; grade, center of station............	L. R. & N.	R	138.7
Coushatta; high water, Red River 1892......	U. S. E.	E	135.07
——grade, center of station..................	L. R. & N.	R	144.7
——pipestone bench in courthouse yard......	U. S. E.	P	132.242
——pipestone bench in yard of Methodist Church	U. S. E.	P	133.633
Crichton Station; grade, center of station..	L. R. & N.	R	139.7
——high water Red River 1892.............	L. R. & N.	R	141.7
Desarc Station; grade, center of station....	L. R. & N.	R	148.7
East Point; grade, center of station....	L. R. & N.	R	144.7
Grand Bayou, SECS. 16-21, T. 14 N., R. 9 W.; bank..............................	S. L. B. & S.	L	186.
——SEC. 4, T. 13 N., R. 9 W.; bank....	S. L. B. & S.	L	174.
—— ——bed....	S. L. B. & S.	L	165.
——SEC. 32, T. 13 N., R. 9 W.; bank...	S. L. B. & S.	L	149.
—— ——bed................................	S. L. B. & S.	L	142.
——OLIVER BRIDGE, (ABOUT SEC. 32, T. 13 N., R. 9 W.); top of floor of bridge..	S. L. B. & S.	L	148.7
—— ——high water......................	S. L. B. & S.	L	148.8
Hope; grade, center of station..............	L. R. & N.	R	145.7
Howard P. O.; pipestone bench near cabin, 100 feet southwest of residence and 650 feet south of gin	U. S. E.	P	141.374
Howard P. O.; high water Red River 1892....	U. S. E.	E	148.84
Kenilworth; grade, center of station........	L. R. & N.	R	129.7
Lake End P. O.; pipestone bench back of cabin 2000 feet southeast of Lake End landing and 1000 feet from bank.....	U. S. E.	P	126.431
Lockwood Station; grade, center of station.	L. R. & N.	R	139.7

LOCATION	AUTHORITY	CLASS	ELEV'N
RED RIVER PARISH—*Continued*			
Loggy Bayou, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	152.7
——bank	L. R. & N.	R	148.
——bed of bayou	L. R. & N.	R	126..
——See under Red River.			
Natchitoches Parish line, L. R. & N. R. R.; ground level	L. R. & N.	R	164.
——grade	L. R. & N.	R	157.7
Nicholas Bayou, L. R. & N. BRIDGE; top of stringer	L. R. & N.	R	129.7
Red River, BELL'S (THOS.) PLANTATION; pipestone bench in yard	U. S. E.	P	143.778
——CRICHTON PLANTATION; pipestone bench in yard of two cabins at sharp bend, 1300 feet below residence	U. S. E.	P	137.736
——LOGGY BAYOU; high water Red River 1892	U. S. E.	E	146.48
——root bench in chinaberry at mouth of bayou	U. S. E.	P	143.748
——pipestone bench in yard of Thomas Bell	U. S. E.	P	143.778
——STRINGFELLOWS PLANTATION; pipestone bench near cabin, 100 feet southwest of residence, 650 feet south of gin	U. S. E.	P	141.374
——UPPER BROWNVILLE PLANTATION; pipestone bench back of cabin 2000 feet southeast of Lake End landing and 1000 feet from bank	U. S. E.	P	126.431
Wilson Station; grade, center of station	S.L.B. & S.	R	211.
RICHLAND PARISH			
Alto; 0.6 mile east of, root bench in pin oak in front of Thomason residence, south side of Archibald-Alto road	U. S. E.	P	72.345
——pipe-flange bench in southwest corner of yard of E. H. Cook, 65 feet from Boeuf River	U. S. E.	P	73.983
——zero of Boeuf River gage 1898	U. S. E.	E	— 20.28
——low water Boeuf River, 1899	U. S. E.	E	54.70
——high water Boeuf River, 1882	U. S..E.	E	72.76
——high water Boeuf River, 1892	U. S. E.	E	72.47
Alto-Archibald Road; see Archibald-Alto Road.			
Alto-Charlieville Road, ADILE CHURCH (COLORED); 130 feet west of, root bench in sweet gum on north side of road	U. S. E.	P	73.178
——HARLAND FIELD; pipe-flange bench at northwest corner of store	U. S. E.	P	73.878
——MOUNT ZION CHURCH; 500 feet south of, root-bench on cow oak on west side of lane, 15 feet east of cypress swamp	U. S. E.	P	73.149
——MULHERN PLACE; 0.25 mile south of residence, root-bench on sassafras, west side of lane	U. S. E.	P	75.370
Archibald; pipe-flange bench in northwest corner of yard of J. J. Archibald, 100 feet southeast of station	U. S. E.	P	76.870

LOCATION	AUTHORITY	CLASS	ELEV'N
RICHLAND PARISH—*Continued*			
Archibald—*Continued*			
———1 mile south of, root bench in hickory 50 feet east of N. O. & N. W. track, 500 feet southeast of cabin..............	U. S E.	P	77.601
Archibald-Alto Road, HEMLEY (WM.) PLACE; opposite southeast corner of, bench on black oak, south side of road......	U. S. E.	P	73.191
———LITTLE CREEK METHODIST CHURCH; 165 feet north of, root bench on post oak on south side of road	U. S. E.	P	73.855
———THOMASON RESIDENCE; in front of, root bench on pin oak on south side of road	U. S. E.	P	72.345
———SHADY GROVE CHURCH; 500 feet south of, root bench on sycamore	U. S. E.	P	73.073
Bayou Macon, V. S. & P. CROSSING; pipestone (pipe gone) bench on west bank of bayou near R. R. bridge, 125 feet south of track and 40 feet from bayou......	U. S. E.	P	74.211
Bee Bayou; top of rail, center of station......	V. S. & P.	R	88.
Big Creek, N. O. & N. W. CROSSING; root bench in sweet gum, west of track, 150 feet north of end of trestle...........	U. S. E.	P	72.221
Boeuf River, ADILE CHURCH; 130 feet west of root bench on sweet gum on north side of road........	U. S. E.	P	73.178
———ALTO; pipe-flange bench in southwest corner of yard of E. H. Cook............	U. S. E.	P	73.983
———CHARLIEVILLE, root bench in walnut in front of warehouse	U. S. E.	P	69.898
———HARLAND FIELD; pipe-flange bench at northwest corner of store	U. S. E.	P	73.878
———HOLLY GROVE LANDING; pipe-flange bench in northwest corner of yard at residence of Frank Hatch....	U. S. E.	P	70.147
——— ——— root bench on catalpa at up stream corner of Frank Hatch's warehouse.	U. S. E.	P	70.288
——— OPPOSITE LANDERNAU; pipe-flange bench, 130 feet east of Green Grove Church.........	U. S. E.	P	68.412
———MC INTOSH PLACE; root bench in sweet gum, on bank of river 650 feet below residence of R. McIntosh............	U. S. E.	P	66.680
———MUDDY BAYOU; pipe-flange bench on left top bank	U. S. E.	E	55.84
———NOBLE PLACE; pipe-flange bench 130 feet from left bank, in pasture near road from Holly Grove Landing....... ...	U. S. E.	P	67.598
———N. O. & N. W. BRIDGE; top of rail......	N. O. & N. W.	R	80.
Point Jefferson; high water 1892...........	U. S. E.	E	93.14
——— ——— zero of gage...	U. S. E.	E	—20.35
———STOKES PLACE; pipe-flange bench, 130 feet from river, 500 feet below residence.	U. S. E.	P	72.282
——— ——— pipe-flange bench, 65 feet above cabin of Henry Hunter.............	U. S. E.	P	72.443

LOCATION	AUTHORITY	CLASS	ELEV'N
RICHLAND PARISH—*Continued*			
Point Jefferson—*Continued*			
——V. S. & P. CROSSING; pipestone bench on east bank, 1.5 miles east of Girard, 230 feet south of track	U. S. E.	P	80.023
Burke Station; pipe-flange bench, 165 feet east of track, 30 feet north of road...	U. S. E.	P	75.639
Carpenter Station; pipestone bench in yard of cabin opposite railroad platform..	U. S. E.	P	86.392
Charlieville; root bench in walnut in front of warehouse...................... ...	U. S. E.	P	69.898
——opposite, pipe-flange bench, 130 feet from river, 500 feet below Stokes residence	U. S. E.	P	72.282
——high water Boeuf River 1882	U. S. E.	E	70.24
——high water Boeuf River 1892	U. S. E.	E	68.93
Crew Lake; pipestone bench in garden northwest of station 75 feet from track....	U. S. E.	P	67.449
——top of rail, center of station	V. S. & P.	R	76.7
Delhi; pipestone bench in W. T. Insley's yard, 65 feet east of Catholic Church yard .	U. S. E.	P	94.307
——top of rail, center of station	V. S. & P.	R	97.9
——high water, Bayou Maçon, 1882	U. S. E.	E	88.28
——high water, Bayou Maçon, 1892	U. S. E.	E	84.28
——low water, Bayou Maçon, 1886	U. S. E.	E	49.80
——zero of gage	U. S. E.	E	50.62
——bench mark on Northeast corner of brick pier at northeast corner of S. Blum's store	U. S. E.	P	96.390
——0.6 mile south of, root bench east side of Delhi-Warsaw road........	U. S. E.	P	95.821
Delhi-Warsaw road, ARMSTRONG PLACE; root bench in cow oak on right bank of bayou 980 feet south of house.....	U. S. E.	P	81.763
——PHILLIPS (S.) PLACE; 45 feet south of, root bench in sweet gum on east side of road..	U. S. E.	P	90.985
——PORTER PLACE; 100 feet south of, root bench in hickory 131 feet south of swale.................	U. S. E.	P	84.062
——PUSSY BAYOU; root bench in white oak 725 feet north of culvert over bayou..	U. S. E.	P	87.864
Girard; high water Boeuf River, 1886.........	U. S. E.	E	80.05
——low water Boeuf River, 1899.............	U. S. E.	E	52.16
——low water Boeuf River, 1886.............	U. S. E.	E	53.74
——zero of Boeuf River, gauge 1886.........	U. S. E.	E	52.88
——top of rail center of station............ .	V. S. & P.	R	87.3
——pipestone bench 13 feet east of Mrs. Broshear's house.................... ...	U. S. E.	P	79.197
——copper bolt in east chimney of Mrs. Broshear's house......................	U. S. E.	P	86.224
——1.5 miles east of, pipestone bench on east bank of Bayou Boeuf, 230 feet south of track........................ ...	U. S. E.	P	80.023
Holly Ridge; top of rail, center of station.....	V. S. & P.	R	90.9

LOCATION	AUTHORITY	CLASS	ELEV'N
RICHLAND PARISH—*Continued*			
Holly Ridge—*Continued*			
——pipestone bench in yard of W. F. Winstead, 6 feet west of entrance........	U. S. E.	P	84.998
Landernau; opposite, pipe-flange bench 130 feet southeast of Green Grove Church	U. S. E.	P	68.412
Mangham; pipe-flange bench in southeast corner of yard of H. H. Nash	U. S. E.	P	74.629
Rayville; top of rail, center of station.... .. .	N. O. & N. W.	R	80.4
——top of rail, center of station	V. S. & P.	R	85.9
——pipe-flange bench 3 feet north of north wall of courthouse	U. S. E.	P	80.317
——copper bolt in face of "L" of courthouse front............	U. S. E.	P	87.959
SABINE PARISH			
Bayou Toro, K. C. S. CROSSING; top of rail opposite milepost 646.5..............	K. C. S.	R	206.00
—— ——high water.......................	K. C. S.	R	201.
—— ——bottom land...	K. C. S.	R	194.
—— ——bed of bayou.....	K. C. S.	R	182.
Bear Creek, K. C. S. CROSSING; top of rail at south end of bridge................	K. C. S.	R	225.69
——bed of creek...............	K. C. S.	R	210.
Buvens Bayou, K. C. S. CROSSING; top of rail at south end of bridge..............	K. C. S.	R	212.
—— ——bottom land	K. C. S.	R	203.
—— ——bed of bayou.................. ...	K. C. S.	R	190.5
Christie; 2 miles north of, rail end bench 10 feet west of milepost 645....	K. C. S.	P	212.69
——1.5 miles north of, rail end bench 18 feet west of milepost 645.5.............	K. C. S.	P	204.78
——1 mile north of, rail end bench 18 feet west of second telegraph pole south of milepost 646.....	K. C. S.	P	207.22
——0.5 mile north of, rail end bench 60 feet north of second telegraph pole south of milepost 646.5...........	K. C. S.	P	197.87
——rail end bench 15 feet southwest of milepost 647	K. C. S.	P	202.07
——0.5 mile south of, rail end bench 10 feet west of milepost 647.5....	K. C. S.	P	213.92
——1 mile south of, rail end bench 35 feet northwest of first telegraph pole north of milepost 648.	K. C. S.	P	215 59
——1.5 miles south of, rail end bench 10 feet northwest of third telegraph pole south of milepost 648.5.	K. C. S.	P	232.66
——2 miles south of, rail end bench 40 feet south of milepost 649................	K. C. S.	P	245.96
——2.5 miles south of, rail end bench 55 feet south of second telegraph pole north of milepost 650.........	K. C. S.	P	295.33
——3 miles south of, rail end bench 65 feet south of milepost 650.5............	K. C. S.	P	320.56

LOCATION	AUTHORITY	CLASS	ELEV'N
SABINE PARISH—*Continued*			
Christie—*Continued*			
——3.5 miles south of, rail end bench 65 feet south of first telegraph pole north of milepost 651	K. C. S.	P	338.74
Choctaw Bayou, K. C. S. CROSSING; top of rail at pile opening	K. C. S.	R	209.38
—— ——bottomland	K. C. S.	R	197.
—— ——bed of bayou	K. C. S.	R	196.
Converse; 4 miles north of, rail end bench 50 feet south of third telegraph pole south of mile post 606	K. C. S.	R	223.52
——3.5 miles north of, rail end bench 40 feet northwest of milepost 606.5	K. C. S.	P	224.85
——3 miles north of, rail end bench 10 feet west of milepost 607	K. C. S.	P	220.10
——2.5 miles north of, rail end bench 25 feet southwest of third telegraph pole south of milepost 607.5	K. C. S.	P	220.23
——2 miles north of, rail end bench 20 feet west of third telegraph pole south of milepost 608	K. C. S.	P	211.66
——1.5 miles north of, rail end bench 10 feet west of first telegraph pole south of milepost 608.5	K. C. S.	P	215.28
——1 mile north of, rail end bench 15 feet west of milepost 609	K. C. S.	P	200.21
——0.5 mile north of, rail end bench 10 feet west of milepost 609.5	K. C. S.	P	214.96
——rail end bench 15 feet west of milepost 610	K. C. S.	P	210.57
——depot, top of rail, at center	K. C. S.	P	213.61
——0.5 mile south of, rail end bench 10 feet west of milepost 610.5	K. C. S.	P	211.28
——1 mile south of, rail end bench 30 feet north of milepost 611	K. C. S.	P	207.41
——1.5 miles south of, rail end bench 10 feet northwest of first telegraph pole south of milepost 611.5	K. C. S.	P	193.76
——2 miles south of, rail end bench 10 feet west of fourth telegraph pole south of milepost 612	K. C. S.	P	193.58
——2.5 miles south of, bench mark on northeast corner east plate, north pedestal of east pair, water tank	K. C. S.	P	191.89
——3 miles south of, rail end bench 50 feet south of milepost 613	K. C. S.	P	184.29
Cross Lake, K. C. S. CROSSING; top of rail opposite milepost 555	K. C. S.	R	182.00
—— ——bed of lake	K. C. S.	R	163.
——high water	K. C. S.	R	178.
—— ——channel, milepost 555.5	K. C. S.	R	154.50
Estes Bayou, K. C. S. CROSSING; top of rail at south end of bridge	K. C. S.	R	198.00
—— ——bottom land	K. C. S.	R	191.
—— ——bed of bayou	K. C. S.	R	185.

LOCATION	AUTHORITY	CLASS	ELEV'N
SABINE PARISH—*Continued*			
Fisher; 0.8 mile north of, rail end bench 12 feet southwest of first telegraph pole south of milepost 638	K. C. S.	P	361.06
——0.3 mile north of, rail end bench 10 feet west of first telegraph pole south of milepost 638.5	K. C. S.	P	341.87
——0.2 mile south of, rail end bench 90 feet south of fourth telegraph pole south of milepost 639	K. C. S.	P	324.36
——0.7 mile south of, rail end bench 65 feet north of milepost 639.5	K. C. S.	P	304.44
Florien; 2.3 miles north of, rail end bench 30 feet north of milepost 640	K. C. S.	P	296.05
——1.8 miles north of, rail end bench 60 feet south of first telegraph pole south of milepost 640.5	K. C. S.	P	289.42
——1.3 miles north of, rail end bench 35 feet south of milepost 641	K. C. S.	P	273.07
——0.8 mile north of, rail end bench 20 feet southwest of milepost 641.5	K. C. S.	P	271.32
——0.3 mile north of, rail end bench 60 feet north of second telegraph pole south of milepost 642	K. C. S.	P	255.91
——0.2 mile south of, rail end bench 10 feet west of milepost 642.5	K. C. S.	P	250.16
——0.7 mile south of, rail end bench 15 feet west of milepost 643	K. C. S.	P	234.07
——1.2 miles south of, rail end bench, 75 feet north of first telegraph pole south of milepost 643.5	K. C. S.	P	229.95
——1.7 miles south of, rail end bench 15 feet southwest of first telegraph pole south of milepost 644	K. C. S.	P	234.23
——2.2 miles south of, rail end bench 80 feet north of milepost 644.5	K. C. S.	P	222.59
Harpoon Bayou, K. C. S. CROSSING; top of rail at north end of bridge	K. C. S.	R	212.00
—— ——bottom land	K. C. S.	R	210.
—— ——bed of bayou	K. C. S.	R	194.
La Nana Bayou, K. C. S. CROSSING; top of rail at north end of bridge	K. C. S.	R	236.00
—— ——bottom land	K. C. S.	R	230.
—— ——bed of bayou	K. C. S.	R	216.
Loring; 1 mile north of, rail end bench 70 feet north of milepost 624.5	K. C. S.	P	271.57
——0.5 mile north of, rail end bench 20 feet west of first telegraph pole north of milepost 625	K. C. S.	P	266.97
——rail end bench, 50 feet north of second telegraph pole north of milepost 625.5	K. C. S.	P	282.89
——0.5 mile south of, rail end bench 20 feet northwest of second telegraph pole south of milepost 626	K. C. S.	P	271.97

LOCATION	AUTHORITY	CLASS	ELEV'N
SABINE PARISH—*Continued*			
Loring—*Continued*			
——.15 mile south of, rail end bench 10 feet west of first telegraph pole south of mile post 626.	K. C. S.	P	274.21
——1.5 miles south of, rail end bench 20 feet southwest of third telegraph pole south of milepost 627	K. C. S.	P	268.31
Many; 5.8 miles north of, rail end bench, 8 feet west of first telegraph pole south of milepost 627.5	K. C. S.	P	288.31
——5.3 miles north of, rail end bench 15 feet southwest of first telegraph pole south of milepost 628	K. C. S.	P	290.09
——4.8 miles north of, rail end bench 10 feet west of first telegraph pole south of milepost 628.5	K. C. S.	P	266.21
——4.3 miles north of, rail end bench 10 feet west of first telegraph pole south of milepost 629	K. C. S.	P	239.71
——3.8 miles north of, rail end bench 40 feet north of second telegraph pole south of milepost 629.5	K. C. S.	P	229.36
——3.3 miles north of, rail end bench 25 feet southwest of milepost 630	K. C. S.	P	216.82
——2.8 miles north of, rail end bench 45 feet north of milepost 630.5	K. C. S.	P	224.76
——2.3 miles north of, rail end bench 18 feet southwest of first telegraph pole north of milepost 631	K. C. S.	P	226.71
——1.8 miles north of, rail end bench 18 feet west of milespost 631.5	K. C. S.	P	210.01
——1.3 miles north of, rail end bench 10 feet west of third telegraph pole south of milepost 632	K. C. S.	P	213.11
——0.8 mile north of, rail end bench 10 feet west of milepost 632.5	K. C. S.	P	210.91
——0.3 mile north of, rail end bench 10 feet west of milepost 633	K. C. S.	P	234.22
——depot, top of rail, at center	K. C. S.	R	239.00
——0.2 mile south of, rail end bench 20 feet west of milepost 633.5	K. C. S.	P	239.92
——0.7 mile south of, bench mark on northwest corner east plate, north pedestal of west pair of water tank	K. C. S.	P	237.08
——1.2 miles south of, rail end bench 10 feet west of first telegraph pole south of milepost 634.5	K. C. S.	P	238.55
——1.7 miles south of, rail end bench 10 feet west of third telegraph pole south of milepost 635	K. C. S.	P	259.25
——2.2 miles south of, rail end bench 10 feet west of second telegraph pole south of milepost 635.5	K. C. S.	P	283.87

LOCATION	AUTHORITY	CLASS	ELEV'N
SABINE PARISH—*Continued*			
Loring—*Continued*			
——2.7 miles south of, rail end bench 110 feet south of milepost 636	K. C. S.	P	302.70
——3.2 miles south of, rail end bench 10 feet west of first telegraph pole north of milepost 636.5	K. C. S.	P	327.15
——3.7 miles south of, rail end bench 15 feet northwest of first telegraph pole north of milepost 637	K. C. S.	P	349.75
——4.2 miles south of, rail end bench 20 feet southwest of milepost 637.5	K. C. S.	P	371.45
Many-Negreet Road, CARROLL PLACE; root bench in oak, center of road, southwest of house	Veatch	L	247.
——LA NANA CHURCH; Sec. 32, T. 7 N., R. 11 W., road in front of	Veatch	L	286.
——M. E. CHURCH, northeast quarter of south east quarter of Sec. 14, T. 6 N., R. 12 W., ten-penny nail in top of foundation block at northwest corner of church	Veatch	L	235.
——TAR CREEK BRIDGE; top of side rail	Veatch	L	210.
Midkiff Bayou, K. C. S. CROSSING; top of rail at north end bridge	K. C. S.	R	351.7
——bed of bayou	K. C. S.	P	331.
Negreet, NEGREET CHURCH; root bench in twin pin oak west of road, 100 feet southwest of church, cross blazed above bench	Veatch	L	209.
——CURTIS STORE; ground	Veatch	L	207.
Nash's Mill Creek; K. C. S. CROSSING; north end bridge, top of rail	K. C. S.	R	218.64
—— ——bed of creek	K. C. S.	P	201.5
Noble; 2.9 miles north of, rail end bench 15 feet southwest of milepost 613.5	K. C. S.	P	185.15
——2.4 miles north of, rail end bench 12 feet west of second telegraph pole south of milepost 614	K. C. S.	P	190.32
——1.9 miles north of, rail end bench 18 feet northwest of second telegraph pole south of milepost 614.5	K. C. S.	P	207.95
——1.4 miles north of, rail end bench 12 feet west of first telegraph pole south of milepost 615	K. C. S.	P	232.71
——0.9 miles north of, rail end bench 50 feet northwest of first telegraph pole south of milepost 615.5	K. C. S.	P	251.01
——0.4 mile north of, rail end bench 10 feet southwest of milepost 616	K. C. S.	P	267.83
——0.1 mile south of, rail end bench 10 feet northwest of first telegraph pole north of milepost 616.5	K. C. S.	P	277.67
——0.6 mile south of, rail end bench 10 feet southwest of second telegraph pole south of milepost 617	K. C. S.	P	253.22

LOCATION	AUTHORITY	CLASS	ELEV'N
SABINE PARISH—*Continued*			
Noble—*Continued*			
——1.1 miles south of, rail end bench 10 feet northwest of first telegraph pole north of milepost 617.5	K. C. S.	P	229.38
——1.6 miles south of, rail end bench 65 feet north of first telegraph pole south of milepost 618	K. C. S.	P	222.73
——2.1 miles south of, rail end bench 65 feet north of milepost 618.5	K. C. S.	P	217.41
——2.6 miles south of, rail end bench 45 feet north of first telegraph pole south of milepost 619	K. C. S.	P	202.05
Pleasant Hill ; grade, center of station	T. & P.	R	284.6
Plymouth ; top of rail, .2 north of milepost 624	K. C. S.	R	277.6
San Patrice Bayou, K. C. S. CROSSING ; 640 feet north of milepost 613, top of rail at end of bridge	K. C. S.	R	192.00
—— ——bed of bayou	K. C. S.	R	177.
——bottom land, 1500 feet south of bridge	K. C. S.	R	184.
Sodus ; grade, center of station	T. & P.	R	284.6
Zwolle ; 2.2 miles north of, rail end bench 90 feet north of milepost 619.5	K. C. S.	P	196.68
——1.7 miles north of, rail end bench 90 feet north of milepost 620	K. C. S.	P	177.97
——1.2 miles north of, rail end bench 30 feet north of milepost 620.5	K. C. S.	P	171.45
——0.7 miles north of, rail end bench 15 feet southwest of milepost 621	K. C. S.	P	178.09
——0.2 mile north of, rail end bench 12 feet south of milepost 621.5	K. C. S.	P	198.35
——depot, top of rail, at center	K. C. S.	R	200.63
——0.3 mile south of, rail end bench 40 feet north of first telegraph pole south of milepost 622	K. C. S.	P	186.00
——0.8 mile south of, rail end bench 15 feet west of milepost 622.5	K. C. S.	P	189.45
——1.3 miles south of, rail end bench 45 feet north of second telegraph pole south of milepost 623	K. C. S.	P	204.90
——1.8 miles south of, rail end bench 20 feet north of first telegraph pole south of milepost 623.5	K. C. S.	P	230.90
——2.3 miles south of, rail end bench 18 feet west of milepost 624	K. C. S.	P	248.58
TENSAS PARISH			
Mississippi River, DUCK POND PLANTATION ; copper bolt in brick chimney of gin house	U.S.C.&G.S.	P	76.035
——HARD TIMES PLANTATION ; copper bolt in cement block near cabin, 150 feet south of Lake St. Joseph	U.S.C.&G.S.	P	79.094
——KEMP'S LANDING ; marble post at W. H. Goldman's residence	U.S.C.&G.S.	P	72.472

LOCATION	AUTHORITY	CLASS	ELEV'N
TENSAS PARISH—*Continued*			
Mississippi River—*Continued*			
——L'ARGENT LANDING, AGNASCO PLANTATION; cut in cistern marked U. S. B. M., about 150 feet southwest of Mrs. Moreland's house	U.S.C.&G.S.	P	69.282
——L'ARGENT, DUNCAN PLANTATION; copper tack in post at end of old levee	U.S.C.&G.S.	P	71.617
——PANOLO PLANTATION; copper bolt in brick chimney of gin house	U.S.C.&G.S.	P	81.692
——POINT PLEASANT PLANTATION; copper bolt in north chimney of dwelling	U.S.C.&G.S.	P	87.779
——RIVERSIDE PLANTATION; copper bolt in east chimney of dwelling	U.S.C.&G.S.	P	83.326
——VILLA CLARA PLANTATION; (opposite Rodney, Miss.) marble post at front entrance of Capt. E. L. Whitney's residence	U.S.C.&G.S.	P	70.972
——WATERPROOF; marble post at A. P. Martin's residence	U.S.C.&G.S.	P	67.203
—— ——3 miles below, top of cistern marked "U. S. B. M., 1881," about 150 feet from main levee	U.S.C.&G.S.	P	67.803
——WAVELAND PLANTATION; copper bolt in brick chimney of gin house	U.S.C.&G.S.	P	78.219
New Light; pipe-flange bench in northeast corner of yard of James R. Lynch, 30 feet from river	U. S. E.	P	71.719
New Light, Como Road; south side of, root bench in white oak, 500 feet west of Roaring Bayou	U. S. E.	P	58.329
——south side of, root bench on pin oak, 325 feet from Cross Bayou	U. S. E.	P	61.770
——south side of, opposite mouth of Mound Bayou, root bench in pecan 260 feet west of cabin	U. S. E.	P	68.583
Tensas River, MYER PLACE; root bench in pecan opposite mouth of Mound Bayou, 260 feet west of cabin	U. S. E.	P	68.583
——MOUND BAYOU PLACE; root bench in pin oak in yard of I. S. Osborne	U. S. E.	P	71.383
——MOUND BAYOU; opposite mouth of, root bench in pecan on south side of road 260 feet west of cabin on Myer Place	U. S. E.	P	68.583
—— —— high water 1893	U. S. E.	E	72.21
—— —— zero of gage	U. S. E.	E	22.83
—— NEW LIGHT; pipe-flange bench in northeast corner of yard of James R. Lynch	U. S. E.	P	71.719
UNION PARISH			
Bayou Cornie Creek, A. S. CROSSING; top of rail	A. S.	R	106.
—— ——bank of creek	A. S.	R	101.
—— ——bed of creek	A. S.	R	79.

LOCATION	AUTHORITY	CLASS	ELEV'N
UNION PARISH—*Continued*			
Bayou Cornie Creek—*Continued*			
——SCOTT'S BLUFF; pipe-flange bench on right bank of bayou and 60 feet below old warehouse	U. S. E.	P	75.846
——SCOTT'S LANDING; high water, 1874	U. S. E.	E	83 85
——STEIN'S BLUFF; near high water, 1874	U. S. E.	E	84.08
Bayou d'Arbonne, COX FERRY; root bench in post oak on right bank below mouth of slough	U. S. E.	P	65.722
—— ——high water, 1874	U. S. E.	E	82.97
—— ——high water, 1883	U. S. E.	E	72.60
—— ——on right bank of, 85 feet below Cox Ferry road, pipe-flange bench	U. S. E.	P	70.583
Bernice; top of rail center of station	A. S.	R	226.
——one mile north of, summit between Corney and Middle Fork	A. S.	R	239.
Cox Ferry, see under Bayou D'Arbornne.			
Farmerville; pipe-flange bench in northwest corner of courthouse yard	U. S. E.	P	179.459
Farmerville-Port Union Road, COLSON (P. O.); road junction, root bench in conspicuous red oak on top of hill	U. S. E.	P	182.087
——root bench in twin cherry tree 250 feet west of crossroad to Echels Ford	U. S. E.	P	181.112
——FARMERVILLE; second hill from, root bench in sweet gum to left, opposite two cabins in field	U. S. E.	P	153.293
——HAY'S PLACE; pipe-flange bench in W. T. Hay's yard	U. S. E.	P	135.173
——HOFFMAN'S HOUSE; 500 feet east of, root bench in post oak, to left and about 150 feet south of cabin	U. S. E.	P	97.513
——POINT PLEASANT BAPTIST CHURCH; 1332 feet east of, root bench in pin oak in small swale	U. S. E.	P	149.031
——PURDUE (JIM) RESIDENCE; 0.25 mile east of, boat spike in pine, left of road and 35 feet east of small branch	U. S. E.	P	155.426
——ROCKY BRANCH; top of hill west of, boat spike in pin oak in front of J. T. Slack's house	U. S. E.	P	156.740
——ROGER'S (PATTISON) PLACE; pipe-flange bench in yard on lower road	U. S. E.	P	175.370
——SIXTEENTH CREEK; top of hill west of, root bench in white oak on right of road	U. S. E.	P	110.853
——SLACK PLACE; boat spike in pin oak in front of house of J. T. Slack	U. S. E.	P	156.740
——TAYLOR (W. W.) PLACE; root bench in pine 1200 feet south of road, in front of dwelling	U. S. E.	P	118.631
——TUCKER CREEK; see SIXTEENTH CREEK.			
——UNDERWOOD'S (JIM) PLACE; 850 feet west of house, root bench in post oak 32 feet north of road	U. S. E.	P	118.235

LOCATION	AUTHORITY	CLASS	ELEV'N
UNION PARISH—*Continued*			
Farmerville-Port Union Road—*Continued*			
—— —— east of dwelling at end of level stretch, root bench in white oak at top of hill	U. S. E.	P	131.293
——WARD PLACE; root bench in hickory north of road, 125 feet from southeast corner of house of John Ward	U. S. E.	P	181.383
——WHITE (WILLIAM) PLACE; in yard of, pipe-flange bench, at juncture of Farmerville, Ouachita City, and Port Union roads	U. S. E.	P	179.045
——root bench in post oak, north side of road, 250 feet west of fork of Lower and Middle roads to Port Union	U. S. E.	P	167.025
Junction City;	A. S.	R	164.
Lillie;	A. S.	R	120.
Middle Fork Creek, A. S. CROSSING; top of rail	A. S.	R	114.3
—— ——bank of creek	A. S.	R	109.
—— ——bed of creek	A. S.	R	96.
Ouachita River, ARKANSAS-LOUISIANA STATE LINE; pipe-flange bench, 292 feet from right bank and 2000 feet below small cabin on left bank	U. S. E.	E	64.56
——ALABAMA LANDING; pipe-stone bench on road, 150 feet southwest of store	U. S. E.	P	69.477
—— ——high water 1882	U. S. E.	E	85.79
——FISHTRAP SHOALS; 1650 feet below, 262 feet west of river	U. S. E.	P	69.511
——FRANK PIERCE CREEK; 165 feet above mouth of, pipe-stone bench on left bank	U. S. E.	P	55.826
——MILL BAYOU, pipe-stone bench on left bank, 800 feet above mouth	U. S. E.	P	71.391
——OUACHITA CITY, gas-pipe near store of J. A. Peck, and 265 feet from river	U. S. E.	E	84.94
—— ——zero of gage	U. S. E.	E—	20.28
——SHILOH SHOALS; 650 feet above, pipe-stone bench 300 feet west of river	U. S. E.	P	56.644
Port Union; pipe-flange bench in R. C. Webb yard, 200 feet from river	U. S. E.	P	84.569
Randolph;	A. S.	R	133.
Ryan;	A. S.	R	112.
Scott's Bluff; see under Bayou Cornie.			
Stein's Bluff; see under Bayou Cornie.			
VERNON PARISH			
Barham; 0.3 mile north of, rail end bench, 80 feet north of first telegraph pole north of milepost 653	K. C. S.	P	301.40
——0.2 mile south of, rail end bench, 10 feet west of milepost 653.5	K. C. S.	P	291.35
——0.7 mile south of, rail end bench, 40 feet north of milepost 654	K. C. S.	P	297.94

LOCATION	AUTHORITY	CLASS	ELEV'N
VERNON PARISH—*Continued*			
Bayou Castor, K. C. S. CROSSING; top of rail opposite milepost 670.5	K. C. S.	R	211.
—— ——bottom lands	K. C. S.	R	204.5
—— ——bed of channel	K. C. S.	R	194.5
Bayou Zourie, K. C. S. CROSSING; top of rail opposite milepost 675	K. C. S.	R	210.
—— ——bottom lands	K. C. S.	R	201.
—— ——bed of channel	K. C. S.	R	185.
Burtons (Palmetto) Creek; Sec. 33, T. 2 N., R. 7 W	A. & W.	L	250.
Calcasieu Parish Line; rail end bench, 10 feet west of milepost 686.5	K. C. S.	P	177.71
Cooper; bench mark on northwest corner of east plate north pedestal of west pair water tank	K. C. S.	P	212.00
East L' Anacoco Bayou; top of rail opposite milepost 660.5	K. C. S.	R	252.
——bottom land	K. C. S.	R	242.
——bed of channel	K. C. S.	R	230.
Flat Creek, K. C. S. BRIDGE; bed of creek	K. C. S.	R	172.
Hawthorne; 0.8 mile north of, rail end bench 12 feet northwest of first telegraph pole north of milepost 663.5	K. C. S.	P	268.50
—— 0.3 mile north of, rail end bench 40 feet southwest of milepost 664	K. C. S.	P	269.56
——station 0.2 mile south of, rail end bench 10 feet west of milepost 664.5	K. C. S.	P	243.26
——0.7 mile south of, rail end bench, 18 feet west of milepost 665	K. C. S.	P	230.47
Hornbeck;* 0.5 mile north of, rail end bench, 10 feet west of milepost 651.5	K. C. S.	P	326.15
——depot, at center, top of rail	K. C. S.	R	310.64
——bench mark on northwest cast plate, north pedestal, water tank	K. C. S.	P	317.01
——0.5 mile south of, rail end bench, 40 feet north of milepost 652.5	K. C. S.	P	311.34
Leesville; 2.8 miles north of, rail end bench, 12 feet northwest of milepost 665.5	K. C. S.	P	246.90
——2.3 miles north of, rail end bench, 40 feet north of milepost 666	K. C. S.	P	260.73
——1.8 miles north of, rail end bench, 30 feet southwest of first telegraph pole north of milepost 665.5	K. C. S.	P	273.72
——1.3 miles north of, rail end bench 12 feet southwest of fifth telegraph pole north of milepost 667	K. C. S.	P	274.83
——0.8 mile north of, rail end bench 12 feet southwest of second telegraph pole north of milepost 667.5	K. C. S.	P	257.70
——0.3 mile north of, rail end bench 25 feet north of first telegraph pole north of milepost 668	K. C. S.	P	234.85

* See also *Christie*, under Sabine Parish.

LOCATION	AUTHORITY	CLASS	ELEV'N
VERNON PARISH—*Continued*			
Leesville—*Continued*			
——depot, at center, top of rail	K. C. S.	R	235.
——0.2 mile south of, rail end bench, 15 feet west of milepost 668.5	K. C. S.	P	233.22
——0.7 mile south of, rail end bench, 8 feet west of milepost 669	K. C. S.	P	225.38
——1.2 miles south of, rail end bench, 45 feet south of first telegraph pole south of milepost 669.5	K. C. S.	P	215.68
——1.7 miles south of, rail end bench, 40 feet southwest of third telegraph pole south of milepost 670	K. C. S.	P	215.00
——2.2 miles south of, rail end bench, 30 feet northwest of milepost 670.5	K. C. S.	P	206.33
——2.7 miles south of, rail end bench, 40 feet south of third telegraph pole south of milepost 671	K. C. S.	P	222.47
——3.2 miles south of, rail end bench, 105 feet south of milepost 671.5	K. C. S.	P	239.04
——3.7 miles south of, rail end bench, 20 feet south of first telegraph pole north of milepost 672	K. C. S.	P	256.20
——4.2 miles south of, rail end bench, 10 feet northwest of first telegraph pole north of milepost 672.5	K. C. S.	P	253.19
——4.7 miles south of, rail end bench, 40 feet north of milepost 673	K. C. S.	P	245.04
——5.2 miles south of, rail end bench, 18 feet northwest of milepost 673 5	K. C. S.	P	255.79
——5.7 miles south of, rail end bench, 55 feet north of milepost 674	K. C. S.	P	244.45
Neame; 2.7 miles north of, rail end bench, 10 feet west of fourth telegraph pole south of milepost 677	K. C. S.	P	283.46
——2.2 miles north of, rail end bench, 8 feet west of first telegraph pole north of milepost 677.5	K. C. S.	P	297.74
——1.7 miles north of, rail end bench, 10 feet west of second telegraph pole south of milepost 678	K. C. S.	P	321.05
——1.2 miles north of, rail end bench, 10 feet west of milepost 678.5	K. C. S.	P	304.72
——0.7 mile north of, rail end bench, 35 feet north of milepost 679	K. C. S.	P	279.60
——0.2 mile north of, rail end bench, 60 feet north of first telegraph pole south of milepost 679 5	K. C. S.	P	272.73
——0.3 mile south of, rail end bench, 10 feet north of milepost 680	K. C. S.	P	274.97
——0.8 mile south of, rail end bench, 7 feet west of milepost 680.5	K. C. S.	P	256.89
——1.3 miles south of, rail end bench, 8 feet west of milepost 681	K. C. S.	P	250.30

LOCATION	AUTHORITY	CLASS	ELEV'N
VERNON PARISH—*Continued*			
Neame—*Continued*			
——1.8 miles south of, rail end bench, 85 feet south of first telegraph pole south of milepost 681.5	K. C. S.	P	239.52
Orange; 4 miles north of, rail end bench, 10 feet west of first telegraph pole north of milepost 654.5	K. C. S.	P	297.05
——3.5 miles north of, bench mark on northwest corner of present top step end of north abutment, A-655	K. C. S.	P	277.26
——3 miles north of, rail end bench, 10 feet west of milepost 655.5	K. C. S.	P	302.47
——2.5 miles north of, rail end bench, 45 feet south of first telegraph pole south of milepost 656	K. C. S.	P	330.84
——2 miles north of, rail end bench, 10 feet west of second telegraph pole north of milepost 656.5	K. C. S.	P	318.67
——1.5 miles north of, rail end bench, 30 feet northwest of sixth telegraph pole south of milepost 657	K. C. S.	P	276.05
——1 mile north of, rail end bench, 25 feet southwest of first telegraph pole north of milepost 657.5	K. C. S.	P	365.00
——0.5 mile north of, rail end bench, 30 feet southwest of first telegraph pole north of milepost 658	K. C. S.	P	343.30
——rail end bench, 95 feet south of milepost 658.5	K. C. S.	P	338.05
——0.5 mile south of, rail end bench, 60 feet south of fifth telegraph pole south of milepost 659	K. C. S.	P	314.30
——1 mile south of, rail end bench, 10 feet west of milepost 659.5	K. C. S.	P	294.73
——1.5 mile south of, rail end bench, 8 feet west of milepost 660	K. C. S.	P	268.78
——2 miles south of, rail end bench, 50 feet south of second telegraph pole south of milepost 660.5	K. C. S.	P	251.50
——2.5 miles south of, rail end bench, 8 feet west of milepost 661	K. C. S.	P	267.68
——3 miles south of, rail end bench, 10 feet west of milepost 661.5	K. C. S.	P	298.80
——3.5 miles south of, rail end bench, 25 feet southwest of first telegraph pole north of milepost 662	K. C. S.	P	286.21
——4 miles south of, rail end bench, 40 feet southwest of third telegraph pole south of milepost 662.5	K. C. S.	P	299.77
——4.5 miles south of, rail end bench, 10 feet west of milepost 663	K. C. S.	P	289.62
"Palmer" (St. Johns ?) Creek; Sec. 30, T. 2 N., R. 7 W	A. & W.	L	260.

LOCATION	AUTHORITY	CLASS	ELEV'N
VERNON PARISH—*Continued*			
Pickering; 0.6 mile north of, rail end bench, 105 feet north of milepost 675.5	K. C. S.	P	215.96
——0.1 mile north of, rail end bench, 70 feet south of second telegraph pole north of milepost 676	K. C. S.	P	223.51
——0.4 mile south of, rail end bench, 80 feet north of first telegraph pole north of milepost 676.5	K. C. S.	P	250.63
Prairie Creek; Sec. 13, T. 3 N., R. 9 W.....	A. & W.	L	280.
——K. C. S. CROSSING; 200 feet north of milepost 665, top of rail	K. C. S.	R	237.
—— —— bottom land	K. C. S.	R	229.
—— —— bed of channel	K. C. S.	R	217.5
Rose Pine; 1.7 miles north of, rail end bench 45 feet south of third telegraph pole south of milepost 682	K. C. S.	P	222.06
——1.2 miles north of, rail end bench, 30 feet south of first telegraph pole north of milepost 682.5....	K. C. S.	P	208.29
——0.7 mile north of, rail end bench, 10 feet west of milepost 683....	K. C. S.	P	210.00
——0.2 mile north of, rail end bench, 15 feet southwest of milepost 683.5....	K. C. S.	P	224.63
——0.3 mile south of, rail end bench, 7 feet south of milepost 684	K. C. S.	P	222.18
——0.8 mile south of, rail end bench, 70 feet north of milepost 684.5....	K. C. S.	P	204.31
——1.3 miles south of, rail end bench, 60 feet northwest of first telegraph pole south of milepost 685....	K. C. S.	P	177.70
——1.8 miles south of, rail end bench, 40 feet south of milepost 685.5....	K. C. S.	P	179.88
——2.3 miles south of, rail end bench, 15 feet northwest of milepost 686	K. C. S.	P	167.86
——2.8 miles south of, rail end bench, 10 feet west of milepost 686.5....	K. C. S.	P	177.71
Sabine River, 1 MILE SOUTH OF TOLEDO; water level, Nov. 16, 1902....	A. & W.	L	90.
—— ——bank level....	A. & W.	L	110.
—— ——top of hills....	A. & W.	L	220.
Sandy Creek; Secs. 9–10, T. 2 N., R., 11 W.	A. & W.	L	160.
Sayles Branch, K. C. S. CROSSING; 1200 feet north of milepost 670, top of rail	K. C. S.	R	215.
—— ——bottom land....	K. C. S.	R	109.
—— ——bed of channel....	K. C. S.	R	201.5
West L'Anacoco Bayou, K. C. S. CROSSING; top of rail, middle of bridge	K. C. S.	R	281.5
—— ——bed of channel....	K. C. S.	R	260.00
West Fork L'Anacoco Bayou; Sec. 23, T., 3 N., R. 10 W....	A. & W.	L	230.
Wolf Creek, K. C. S. CROSSING; rail end bench 15 feet northwest of milepost 686....	K. C. S.	P	167.86

LOCATION	AUTHORITY	CLASS	ELEV'N
WEBSTER PARISH			
Arkansas-Louisiana State line; L. & A. R. R.	L. & A.	R	250.
Bayou Bodcau, WEST OF SPRING HILL; high water	L. & A.	R	174.
——bed of bayou	L. & A.	R	164.
Brushy Bayou, S. L. B. & S. BRIDGE; top of rail	S. L. B. & S.	R	154.
——bed of bayou	S. L. B. & S.	R	156.
——L. & A. BRIDGE; bed of bayou	L. & A.	R	171.
Cotton Valley; grade, center of station	L. & A.	R	233.
Dorcheat Bayou, L. & A. CROSSING; top of stringer of bridge	L. & A.	R	168.
——bed of bayou	L. & A.	R	143.
—— 2 MILES WEST OF SIBLEY; pipestone bench on east bank, 65 feet south of track	U. S. E.	P	140.911
Doyline	V. S. & P.	R	227.
——east of, root bench in oak north of track and 1300 feet west of milepost 147	U. S. E.	P	202.495
——pipestone bench in Doyle's field southwest of station	U. S. E.	P	223.224
Dubberly; pipestone bench in yard of P. H. McCary	U. S. E.	P	255.943
——top of rail, center of station	V. S. & P.	R	253.9
Heflin; grade, center of station	L. & A.	R	274.
Hortman; grade, center of station	L. & A.	R	183.
Lanesville; see Sibley.			
Lee Wright Creek, L. & A. BRIDGE; Sec. 34, T. 18 N., R. 9 W., top of stringer	L. & A.	R	182.
——bed of bayou	L. & A.	R	169.
Long Springs; grade center of station	L. & A.	R	176.
Minden; grade center of station	L. & A.	R	181.
Sarepta; grade, center of station	L. & A.	R	251.
Sibley Station; top of rail, center of station	V. S. & P.	R	195.4
——grade V. S. & P. crossing	L. & A.	R	193.
——pipestone bench in Mr. Allison's yard, 90 feet south of track	U. S. E.	P	188.980
—— 2 miles west of, pipestone bench on east bank of bayou Dorcheat, near V. S. & P. bridge, 65 feet south of track	U. S. E.	P	140.911
Spring Hill; grade center of station	L. & A.	R	251.
Yellow Pine; head block, saw-mill spur	S. L. B. & S.	R	192.8
WINN PARISH			
Big Creek, A. S. BRIDGE; top of rail north end of	A. S.	R	142.
Calvin Station; grade, center of station	L. & A.	R	173.
Carter; grade, center of station	L. & A.	R	173.
Dodson; top of rail, center of station	A. S.	R	211.6
——1.5 miles north of, top of rail, north end of Big Creek bridge	A. S.	R	142.
——1 mile north of, top of rail, Dean's Branch bridge	A. S.	R	171.2

LOCATION	AUTHORITY	CLASS	ELEV'N
WINN PARISH—*Continued*			
Dugdemona Bayou, A. S. BRIDGE; top of rail	A. S.	R	110.
——— ———bank of bayou	A. S.	R	96.
——— ———bed of bayou	A. S.	R	82.
Grant Parish line; grade L. R. & N. R. R.	L. R. & N.	R	164.
Jackson Parish line; grade A. S. R. R	A. S.	R	170.
Keische Creek, L. & A. BRIDGE; Sec. 8, T. 11 N., R. 3 W.; top of stringer north end of bridge	L. & A.	R	122.
——— ———bank of creek	L. & A.	R	118.
Lyle's Branch, A. S. BRIDGE; Sec. 5, T. 13 S., R. 3 W., top of rail	A. S.	R	161.4
Packton; grade, center of station	L. & A.	R	162.
Port Luce Bayou, L. & A. BRIDGE; top of stringer	L. & A.	R	115.
——— ———bed of bayou	L. & A.	R	101.
———A. S. BRIDGE; top of rail	A. S.	R	100.
——— ———high water	A. S.	R	96.
——— ———bank of bayou	A. S.	R	92.
——— ———bed of bayou	A. S.	R	86.
Pyburn Station; grade	A. S.	R	211.
Saline Bayou, L. & A. BRIDGE; top of stringer	L. & A.	R	120.
——— ———bank of bayou	L. & A.	R	112.
——— ———bed of bayou	L. & A.	R	93.
Sonnet Bayou, L. & A. BRIDGE; Sec. 15, T. 11 N., R. 2 W., top of stringer	L. & A.	R	116.
——— ———bed of bayou	L. & A.	R	105.
St. Maurice; high water	U. S. E.	E	107.87
———pipestone bench in lot southeast of E. W. Tidlie's store	U. S. E.	P	107.688
Tannehill Station; grade	A. S.	R	123.
Winnfield; grade center of station	A. S.	R	124.
———Arkansas-Southern crossing	L. & A.	R	113.
———Arkansas-Southern crossing	L. R. & N.	R	115.
———grade, center of station	L. & A.	R	123.

STATE EXPERIMENT STATION

BULLETIN

OF THE

LOUISIANA

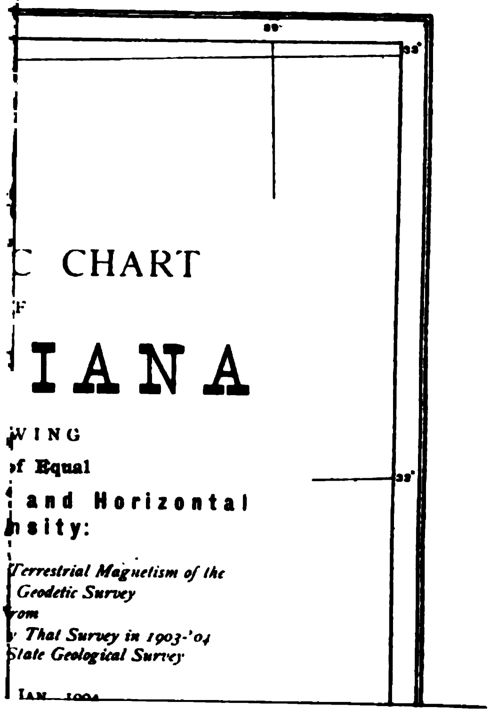
GEOLOGICAL SURVEY

No. 2.

TERRESTRIAL MAGNETISM AND MERIDIAN LINE WORK.

BATON ROUGE

1905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BULL. No. 2 REPORT OF 1905

GEOLOGICAL SURVEY OF LOUISIANA

GILBERT D. HARRIS, *Geologist-in-Charge*

A REPORT

ON

TERRESTRIAL MAGNETISM AND MERIDIAN LINE WORK IN

LOUISIANA

BY

MEMBERS OF THE DIVISION OF TERRESTRIAL MAGNETISM

OF THE

COAST AND GEODETIC SURVEY,

DR. L. A. BAUER, *Division Director*

AND

MEMBERS OF THE STATE GEOLOGICAL SURVEY;

WITH

INTRODUCTORY REMARKS

BY

G. D. HARRIS

MADE UNDER THE DIRECTION OF THE STATE EXPERIMENT STATION,

WM. C. STUBBS, *Director*

BATON ROUGE,

1905

LOUISIANA STATE UNIVERSITY AND A. AND M. COLLEGE

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BY

WM. C. STUBBS

STATE EXPERIMENT STATION,
BATON ROUGE, La., Dec. 29, 1904.

TO HIS EXCELLENCY, NEWTON C. BLANCHARD, GOVERNOR OF LOUISIANA:

Sir:—I have the pleasure to transmit herewith Bulletin No. 2 of the Geological Survey of Louisiana. It shows (1) what has been accomplished by way of establishing meridian lines for the immediate service of every parish surveyor, and (2) what measurements have been made to ascertain the changes that are continually taking place in the earth's magnetic field within the State of Louisiana. Records show *roughly* how the compass pointed in Louisiana 10, 20, or 50 years ago; this Bulletin shows *exactly* the condition of affairs magnetic now. So long as the compass needle is used in surveying, just so long is it of vital importance to understand the nature and amount of changes it is continually undergoing. The desirability of such accurate and permanent records will certainly be appreciated by all surveyors, engineers and land-holders throughout the whole State.

Respectfully submitted,

WM. C. STUBBS, *Director*.

LETTER OF TRANSMITTAL

BY

G. D. HARRIS

LAFAYETTE, La., Dec. 29, '04.

DR. WM. C. STUBBS,
Director of Experiment Stations of Louisiana.

Sir: I have the honor to transmit to you *Bulletin No. 2* of the Louisiana State Geological Survey. By your intimate knowledge of the work of this Survey you already know the general results presented in this Bulletin. But, allow me to call your attention to a few special points.

(1) Through the energy of the Division of Terrestrial Magnetism of the Coast Survey, and grants recently made by the Carnegie Institution at Washington, magnetic surveys are being vigorously prosecuted throughout the United States and its distant possessions. Yet Louisiana is, we believe, but third in the Union to have a satisfactory survey made including all three elements—*declination*, *dip*, and *intensity*. Moreover, though Maryland and North Carolina are ahead of us so far as time is concerned, Louisiana presents a more compact territory, one admitting of a more satisfactory discussion of regional disturbances than either of the two above mentioned states.

(2) Before we commenced the earnest prosecution of magnetic work in Louisiana the various reports dealing with the magnetics of the state indicated that East declination was decreasing at the rate of 3′ per annum. Now our work has proven that former calculations were incorrect, that since about 1898 East declination has been increasing at least 1′ annually.

(3) There seems to be a marked connection between the regional magnetic and geologic disturbances. The discovery of buried

ridges of older rock, through magnetic work, is by no means so impossible as might at first seem. Already such ridges have been traced across southern England by magnetic survey work, and from our present studies it appears that the geologist may receive many important hints from the student of terrestrial magnetics.

(4) Every surveyor in any parish of the State now has a ready means of seeing what the index error of his compass is. First he should set up his instrument over a meridian line say at 5 or 6 o'clock in the evening and sight alone the true north-south line. If his compass needle reads exactly as the declination for the place (brought up to the epoch of his observation) as given in the following Table (I), then there is no index error; if it reads differently, then such difference is the index error of his instrument.

Thanking you for your sympathetic, energetic and efficient coöperation in this work, I remain,

Most respectfully yours,

G. D. HARRIS,

Geologist-in-charge.

INTRODUCTORY REMARKS

BY

G. D. HARRIS

Fifteen years ago while employed as assistant geologist on a neighboring state survey, the writer was asked by the State Geologist: "How much do you suppose it would cost, and how long would it take, to have meridian lines established at every county seat in this state?" The question was duly considered and after the necessary means of transportation, cost of markers, salary for employes, etc., were taken into account, it was believed that perhaps an expenditure of $3500 and a year's time were called for. This seemed discouraging; the work was not taken up.

The same discouraging conditions confronted the writer in 1898 when he was placed in charge of geological work in Louisiana with an annual appropriation of $2000. Yet the desirability of the work (as outlined in former reports) seemed so great that some solution of the difficulty seemed imperative. Accordingly, an engineer's transit (Heller and Brightley's) was borrowed from the Engineering Department of the State University at Baton Rouge and observations were made and markers were left at every parish seat traversed in general geologic work. The only losses thus entailed to geologic work proper were one day after a night's observations, devoted to finding and setting permanent monuments or markers, and the transportation expenses of a few extra instruments.

The same plan of work was continued in the following three years, with a large C. L. Berger tachymeter for observational purposes. But of late our work has become somewhat too localized in Southern Louisiana to call for the visiting of many new parish seats. Vast areas in the alluvial regions, of only secondary interest geologically, seemed likely to be overlooked if no assistance outside the State Survey could be had. Accordingly the U. S. Coast and Geodetic Survey was appealed to, and, for

the good reason that that survey would provide the instruments requisite for making observations for declination, dip, and horizontal intensity, one of the very objects for which meridian lines are established, as explained in our report of 1899.

By referring to Table I of this report it will be seen that "E. S." (Edwin Smith of the U. S. Coast and Geodetic Survey) covered no less than 15 stations in 1903, nine of which were not provided with meridian lines. Bad weather prevented an advantageous prosecution of his work and he returned to Washington in February. The winter of 1903-4 was phenomenally pleasant in Louisiana and the results of "L. B. S. 's" work show for themselves in Table I. In the case of both of these assistants from the Coast Survey, their salaries and living expenses have been met by that organization, while only traveling and incidental expenses have come from the State Survey's funds. Again, not only has the immediate object of the first conceived work been accomplished, *i. e.*, the establishment of meridian lines for the benefit of land surveyors, but also one of the ulterior objects of the work is already realized. We refer to the complete magnetic survey of the state, with accurate measurements of declination, dip, and horizontal intensity as shown by the report which follows.

List of parishes with the character of line established at or near the parish seat :

Acadia;	permanent	meridian	line
Ascension ;	"	"	"
Assumption ;	"	"	"
Avoyelles ;	"	"	"
Bienville ;	"	"	"
Bossier ;	"	"	"
Caddo ;	"	"	"
Calcasieu ;	"	"	"
Caldwell ;	"	stone post, azimuth readings	
Cameron ;	"	meridian	line
Catahoula ;	"	"	"
Claiborne ;	"	"	"
Concordia ;	"	"	"
De Soto ;	"	"	"

East Baton Rouge ;	permanent	meridian	line
East Carroll ;	"	"	"
East Feliciana ;	"	"	"
Franklin ;	permanent	meridian	line
Grant ;	"	"	"
Iberia ;	"	"	"
Iberville ;	"	"	"
Jackson ;	"	"	"
Jefferson ;	"	"	"
Lafayette ;	"	"	"
La Fourche ;	permanent	meridian	line
Lincoln ;	"	"	"
Livingston ;	temporary	"	"
Madison ;	permanent	"	"
Morehouse ;	"	"	"
Natchitoches ;	"	"	"
Orleans ; observation, but no mark			
Ouachita ;	permanent	meridian	line
Plaquemine ;	"	"	"
Pointe Coupée ;	"	"	"
Rapides ;	"	stone post, with azimuth readings	
Red River ;	"	meridian	line
Richland ;	"	"	"
Sabine ;	"	"	"
St. Bernard ;	"	"	"
St. Charles ;	"	"	"
St. Helena ;	"	"	"
St. James ;	"	"	"
St. Martin ;	"	"	"
St. John Baptist ;	"	"	"
St. Landry ;	"	"	"
St. Mary's ;	"	"	"
St. Tammany ;	"	"	"
Tangipahoa ;	"	azimuth	"
Tansas ;	"	meridian	"
Terre Bonne ;	"	"	"
Union ;	"	"	"
Vermillion ; permanent and temporary lines			

Vernon ; temporary azimuth line

Washington ; permanent meridian line

Webster ; " " "

West Baton Rouge ; no meridian line, surveyors should use the one at Baton Rouge

West Carroll ; permanent meridian line

West Feliciana ; no line, use the one at New Roads

Winn ; permanent meridian line

ISOMAGNETIC CHARTS

Isomagnetic charts are constructed for the purpose of showing graphically the condition of terrestrial magnetics over a given area. Plate XI of the present Bulletin is a map or chart of this kind for the state of Louisiana. Notice superimposed upon an outlined map, three systems of more or less curving and broken lines.

ISOGONIC LINES

Up and down across the map are shown heavy lines marked with whole and half degrees, as 6°, 6½°, 7°, etc. These do not show by their direction which way the compass needle points, but indicate the line along which the needle would have a constant bearing (variations or δ) or say 6° or 6½° or 7° E. of north.

Charts representing all or the greater part of the earth's area have been constructed on practically the same principal; see Pl. XII. It is evident that if the declination is decreasing eastward throughout the state of Louisiana, as indicated by the isogonic lines on Pl. I, then somewhere not many hundred miles to the east a line of no variation will be found. This is the *Agonic* line and is clearly shown on Pl. XII.

ISOCLINIC LINES

Every student of elementary physics knows that if a steel bar be suspended centrally and carefully balanced, and afterwards magnetized it no longer maintains its balance or horizontal position, but one end is more or less depressed (except of course at the magnetic equator). It now forms a dip needle. The amount of dip is frequently spoken of as the inclination and is usually represented by the letter I. Lines of equal inclination are spoken of as isoclinics; and by consulting Pl. XI several of such lines may be seen together with the dip or inclination observed along each.

ISODYNAMIC LINES

The third and last element to be determined in magnetic work is the *intensity* of the field. The force acting upon the needle

varies with time and place. Lines representing equal force at any stated epoch are called isodynamic lines. Such lines are shown on Pl. XI agreeing roughly in direction with the isoclinics. The figures represent the horizontal force expressed in c. g. s. (centimeter, gramme, second) system. The decimal point is sometimes moved five places to the right to avoid the use of fractional quantities. The extremely diminutive unit force thus indicated is now generally termed a *gamma* and is indicated by the Greek letter (γ).

TERRESTRIAL MAGNETIC MEASUREMENTS

DECLINATION (δ)

Introductory remarks.—After a meridian line has been established it would seem at first that δ might be determined by sighting over the meridian line and then observing the reading indicated by the needle. When, however, we recall the fact that the needle is constantly changing in direction (from secular, annual and diurnal variation) it is evident that here, as in barometric work, we have need of a stationary or standard instrument for checking up our various readings. Again, it is practically never that the line of sight in transits and compasses, especially the former, corresponds with the zero of the compass box, and it is scarcely ever that the physical axis of the needle corresponds with the magnetic axis.

Hence, before asserting what is the true "variation" of the compass needle at a certain place for a certain time, many things must be taken into consideration, even though the surveyor is furnished with a true meridian line.

Declination from transit or compass observations.—If the surveyor is provided with a transit or compass with horizontal limb he may determine declination over a meridian line as follows :

Set up transit, say, over S. monument of a meridian line, or a few feet or yards N. or S. of the same, at any rate on the meridian line ; clamp 0° of alidade at 0° of limb ; loosen spindle clamp and swing sights till they are upon the N. monument ; clamp spindle ; unclamp alidade and swing practically in mag-

netic meridian: note time; loosen needle, causing it to go through a slight rocking motion by bringing temporarily over either end a bit of steel or a pocket knife; clamp alidade and move tangent screw till N. end of needle is exactly on 0°; read limb vernier; turn screw slightly till S. end of needle is on 0°; read vernier; disturb needle slightly by a bit of steel; bring ends to 0° and read as before.

The average of these readings should indicate the declination at that station for that time except for the index error of the instrument. This can be allowed for as follows: look in the tables of this report and see what the true declination was for 1903 or 1904. Add about 1½′ for the number of years the observation is made after the dates referred to. If the declination thus obtained agrees with that determined by the needle, then there is no index error; if the two differ, the difference is the index error of the instrument. Observations should be made when convenient between 5:30 and 6:30 P. M. to take advantage of the usual magnetic quietude of this time of day and to render unnecessary any large allowance for diurnal variation.

Observations should be repeated on two or three different days to eliminate any possibility of a magnetic storm that might disturb one day's readings.

It is considered desirable by some to use also 5° E. and 5° W. of 0° on the compass circle in place of 0° for some of the many readings that are made. Slightly different conditions are thus brought about between needle and pivot, and a slightly different part of the compass circle graduation is used. The chief advantage in settling the needle on 5° W. and then 5° E. we believe to be in the demand thus made for a large number of readings. If four readings have been made on 0°, then four on 5° E., four on 5° W. and finally four on 0° again there are then sixteen independent readings. It is quite possible that this number would seem excessive to most surveyors, or if the readings were actually made the disturbing of the needle between observations would not be sufficient to insure perfectly independent results. The following outline is therefore suggested for observational purposes:

DECLINATION BLANK

Station........ ....
Observer.................. Date........... ....190....
Instrument................................... .....
Time.......... Com...............A. M. Com ....P. M.
End.. .... " End .... "

Needle on 0°		Needle on 5°	
N. end	S. end	N. end	S. end
....°....′	...°....′	....°....′	....°....′
....	....	....	....
....	....	....	....
....	....	....	....
....	....	... .	....
Sum 4)........	....	....	....

....°....′ means ...°....′
2)....°....′
Result................. ....°....′

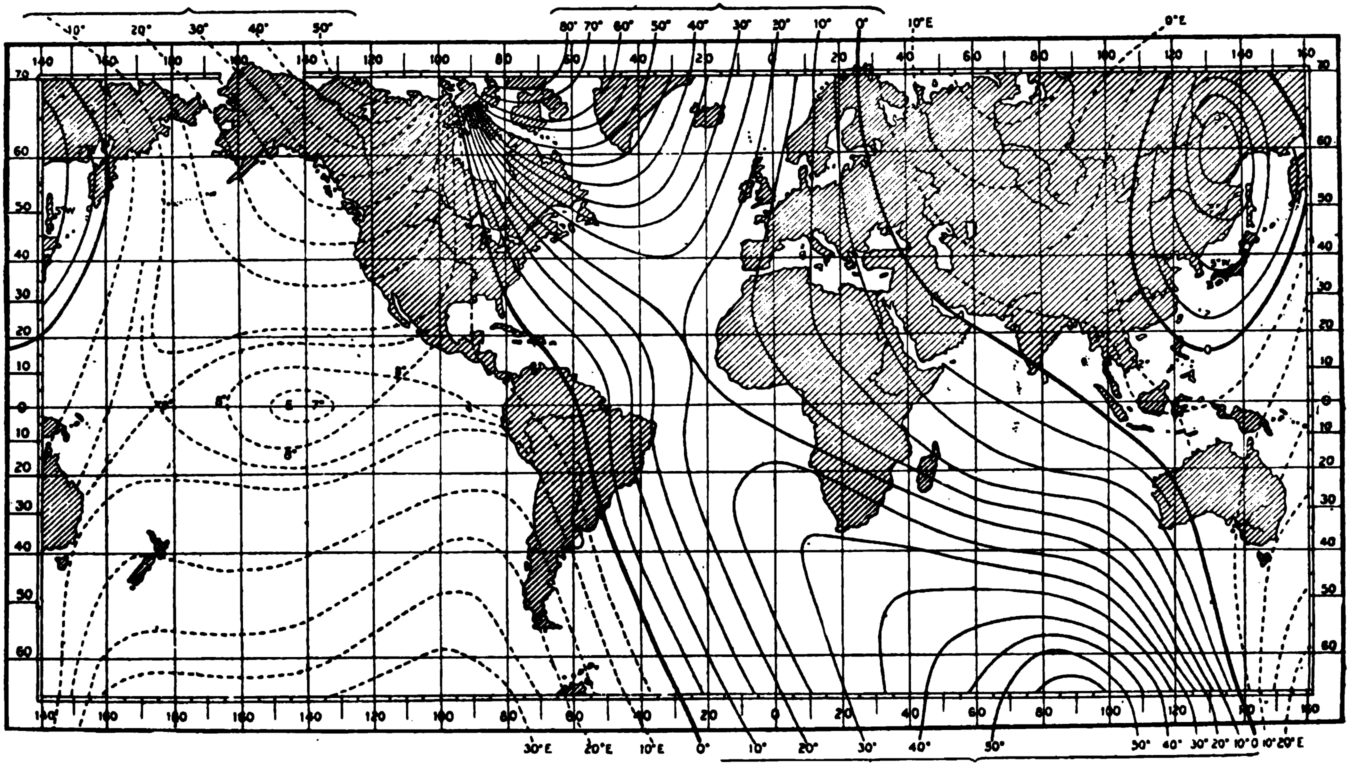
In case readings are made at various hours of the day, they can generally be approximately referred to mean value by use of the following table of corrections (based on three years continuous records at the Naval Observatory at Washington):

Correction of Diurnal Variation

(From U. S. C. & G. Survey Rept.)

	A. M.							P. M.					
	6	7	8	9	10	11	12	1	2	3	4	5	6
	′	′	′	′	′	′	′	′	′	′	′	′	′
January	*0.1	†0.2	†1.0	†2.1	†2.4	†1.2	*1.1	*2.5	*2.6	*2.1	*1.3	*0.2	†0.2
February.	†0.6	†0 7	†1.5	†1 9	†1.4	*0.1	*1.5	*2.1	*2.5	*2.0	*1.2	*0.8	*0.4
March.	†1.2	†2.0	†3.0	†2.8	†1.6	*0.6	*2.5	*3.4	*3 7	*3.3	*2.3	*1.2	*0.5
April......	†2.5	†3.1	†3 4	†2.6	†0.8	*2.1	*4.0	*4.1	*4.2	*3 6	*2.3	*1.2	*0.2
May...	†3.0	†3.8	†3.9	†2.6	†0.1	*2.4	*4.0	*5.0	*4.5	*3.6	*2.3	*0.9	†0.1
June...... ..	†2.9	†4.4	†4.4	†3.3	†1.1	*2.0	*3.6	*4.5	*4.5	*3.8	*2.6	*1.2	*0.2
July........	†3.1	†4.6	†4.9	†3 9	†1.8	*1.2	*3.4	*4.4	*4.7	*4.2	*2.8	*1.3	*0.3
August.	†2.9	†4.9	†5.4	†3 7	†0.4	*2.8	*4.7	*5 1	*4 9	*3.7	*1.9	*0.6	†0.3
September..	†1.8	†2.8	†3.4	†2.5	†0.3	*2.7	*4.4	*4.6	*4.2	*4.0	*1.4	*0.3	*0.1
October	†0 5	†1.6	†3.1	†2.8	†1.4	*1.0	*2.7	*3.3	*3.4	*2.4	*1.3	*0.4	*0.4
November ..	†0.5	†1.2	†1.7	†1.8	†1.1	*0.5	*2.0	*2.7	*2.6	*1.8	*1.0	*0.2	†0.2
December..	†0.2	†0.3	†0 8	†1.8	†1.8	*0 0	*1.6	*2.4	*2.3	*1.8	*1.1	*0.3	†0.1

For *east* declination (as in Louisiana) * means add and † means subtract the number of minutes (′) indicated opposite the month and hour of observation. Generally speaking, the north end of



ISOGONIC CHART OF THE WORLD, AFTER NEUMAYER.

Instrument for Determining Inclination and Relative Intensity

Photo. from Div. Terrest. Magnetism ; U. S. Coast and Geodetic Survey

the needle is too far east in the morning and too far west in the afternoon. The corrections show how much for each hour of the day.

Incidentally it is interesting to note that if a compass sighting is made at 7 or 8 o'c. in the morning in the month of June, July or Aug., and a stake set a mile away; then, if a sighting over the same station with the same magnetic bearing be made early in the afternoon and another stake set a mile off, the two stakes will be 14 to 16 feet apart.

INCLINATION (I)

Plate XIII shows one of the various instruments wherewith not only inclination or dip, but also relative intensity can be determined. The needle within the enclosed framework is a dipping needle and is pointing at a high angle with the horizon.

Inclination is one of the easiest elements to obtain in magnetic work.

As a matter of course inclination or dip is measured in the magnetic meridian. The finding of the latter is very quickly done by revolving the instrument with the dip needle unclamped. When the face or back of the instrument is magnetic north or south the needle will stand vertically for the east-west horizontal component is then zero. Note reading of limb and turn the instrument 90° in azimuth and begin work. By reading the pointings of both ends of the needle, disturbing the same, reading again; by changing circle of instrument east to circle west; by changing needle face east to needle face west; and finally by changing the polarity of the needle by the use of heavy bar magnets, the various instrumental imperfections like lack of symmetry between physical and magnetic axis, improper balancing before magntization, inclination of pivot bearings, etc., can be practically eliminated. By following a fixed program of observation as outlined above with one needle, then with a second, the total average must be not far from correct. To be sure there is generally an index error of perhaps a minute to be applied to each needle, and then too there is a slight correction for diurnal variation, but the latter rarely exceeds 1′ in this latitude.

With the dip circle arranged as indicated by Pl. XIII our own experience leads us to feel sure that the greatest errors are introduced by the lack of straightness of the needles' axis. When the needle is disturbed (lifted) it may be brought down on the bearings twice or three times in about the same way, but again it may be let down with a little more force or it may gradually move a little sidewise on the bearings (i. e. lengthwise of the axis) and then come to rest several times a number of minutes from the average of the former series. Either the axis must be absolutely straight(a physical impossibility) or there should be no chance for a sidewise "shuching" movement.

INTENSITY (H or W)

The instrument shown by Pl. XIII is arranged for determining horizontal intensity by means of Loyds method of deflection.

Here, two needles are used, but in a somewhat different manner than when inclination is sought. First a magnetized needle with a small weight put on one end is first placed in the frame and readings made. Next this needle is placed outside the face circle in the long brass box crossing the circle diametrically while a dip needle takes its place in the frame. In the first instance, gravity is balanced against the earth's magnetic field ; in the second, the magnetic field produced by the weighted magnet and that of the earth are balanced against each other.

At a station where H (horizontal intensity) or W (total intensity is known, observe :

η_0—dip of weighted needle ;

μ'_0—half the difference between readings of deflected needle ;

$\mu^0 = I_0 - \eta_0$;

Then derive a constant C by the following formula :

$$C = H_0 \sec I_0 \sqrt{\sec \eta_0 \sin \mu'_0 \sin \mu_0}$$

H_0 is of course $W_0 \cos I_0$.

Then at another station derive W as follows from observations at that place, using C as already determined:

$$W = C \sqrt{\frac{\cos \eta}{\sin \mu \sin \mu}}$$

VALUE OF MAGNETIC WORK

For ordinary survey work, the value of true declination determinations is too obvious to call for comment here. For the advancement of our knowledge of terrestrial magnetism and for the study of the relationship between this science and stratigraphic geology, dip and intensity measurements are of equal value with declination; that is, areas disturbed stratigraphically, reflect their condition in dip and intensity as well as in declination.

RESULTS OF THE MAGNETIC OBSERVATIONS IN LOUISIANA

BY THE

DIVISION OF TERRESTRIAL MAGNETISM OF THE U. S. COAST AND GEODETIC SURVEY

EXPLANATORY REMARKS

The following two tables give the results of the magnetic observations of known accuracy, on file at present at the Coast and Geodetic Survey. They have been generally obtained with instruments designed for magnetic work.

In Table I the values of the magnetic declination as tabulated have been referred to the mean value for the month in which the observation was made. Thus, for example at Pointe a la Hache, the declination observed on January 2, 1904, at 10:13 A. M., local mean time, was $5^{\circ}22'.7$ East and at 4:19 P. M. local mean time, was $5^{\circ}21'.6$. These two values referred to the middle of January give $5^{\circ}22'.9$ East.

No reductions to mean of month can at present be made for the dip and intensity values; usually these reductions are of the order of error of observation. The values of the horizontal intensity, to avoid decimal quantities, are expressed in terms of the fifth decimal c.g.s. units. (1 gamma or $\lambda = 0.00001$ C.G.S.)

In Table I, the following abbreviations have been used for the observer's name:

L.B.S. L. B. Smith, Coast and Geodetic Survey
E.S. Edwin Smith, " " " "
G.D.H. G. D. Harris, State Geologist
L.A.B. L. A. Bauer, Coast and Geodetic Survey
W.W. W. Weinrich " " " "

Appended will be found as full descriptions as possible of the stations since 1901.

TABLE I.

Results of Magnetic Observations made in Louisiana between 1901 and 1904, under the Auspices of the Coast and Geodetic Survey and the State Geological Survey

Station.	Latitude.		Longitude W. of Gr.		Date.	Declination East.		Dip.		Hor. Int.	Observer.
	°	′	°	′		°	′	°	′	′	
Pointe a la Hache.	29	35.7	89	47.8	1904, Jan. 2	5	22.9	59	47.6	27735	L. B. S.
Houma......	29	35.7	90	43.6	1903, Feb. 17	5	42.6	59	33.8	27893	E. S.
Côte Blanche.....	29	44	91	43	1904, Feb. 16	6	17.8				G. D. H.
Cameron	29	47	93	19	1901, Feb. 28						
					Mar. 1	6	46.0				G. D. H.
Thibodaux.	29	47.6	90	47.4	1903, Feb. 9	5	44.0	59	43.4	27789	E. S.
Franklin	29	48.5	91	30.0	1903, Feb. 18–19	6	02.4	59	33.9	27927	E. S.
					1904, Jan. 7–13	6	05.8	59	42.1	27866	L. B. S. & G. D. H.
Baldwin	29	49.2	91	36	1904, Feb. 15, 18	6	07.7	59	40.2	27999	G. D. H.
Grande Côte......	29	50.2	91	47	1904, Jan. 19–20	6	13.2	59	36.8	28003	G. D. H.
(Weeks' Island) ..											
St. Bernard.......	29	52.6	89	51.0	1903, Dec. 30						
					1904, Mar. 25	5	28.7	59	59.0	27681	L. A. B., L. B. S. & G. D. H.
New Orleans.	29	54	90	08	1901, Apr. 16	5	24.4				W. W.
Avery's Island....	29	55	91	53	1904, Feb. 19	6	21.6				G. D. H.
Gretna.	29	56.2	90	03.1	1904, Jan. 5, 6	5	40.1	60	01.9	27650	L. B. S.
Napoleonville ...	29	56.4	91	00.5	1903, Feb. 5	5	47.4	59	51.4	27756	E. S.
Abbeville	29	58	92	07	1904, Mar. 22, 23	6	28.1	59	41.6	27845	G. D. H.
Hahnville	29	58.3	90	22.2	1903, Feb. 12	5	35.6	59	58.5	27734	E. S.
New Iberia.	30	00	91	48	1904, Feb. 18–19	6	18.4	59	49.3	27927	G. D. H.
Convent..........	30	01.0	90	49.6	1903, Jan. 15	5	45.6	59	57.5	27710	E. S.
Edgard	30	02.0	90	31.6	1903, Feb. 11	5	39.5	60	05.2	27674	E. S.
Donaldsonville. ..	30	06.6	90	57.7	1903, Feb. 2, 3	5	46.5	60	04.8	27629	E. S.
St. Martinville....	30	08	91	49	1904, Feb. 12, 13	6	22.2	60	00.2	27853	G. D. H.
Crowley..........	30	12	92	20	1904, Mar. 8	6	31.8	60	04.6	27727	G. D. H.
Jennings	30	12	92	37	1904, Mar. 16	6	38	60	03.5	27718	G. D. H.

TABLE I.—*Continued.*

Station.	Latitude.		Longitude W. of Gr.		Date.	Declination East.		Dip.		Hor. Int.	Observer.
	°	′	°	′		°	′	°	′	′	
Lafayette.	30	13	92	00	1904, Feb. 2, 4	6	32.4	60	09.4	27633	G. D. H.
Lake Charles.	30	14.2	93	13.0	1904, Jan. 11	6	50.5	60	02.4	27695	L. B. S.
Anse-la-Butte......	30	15	91	56	1904, Feb. 1	6	26.6				G. D. H.
Evangeline........	30	16.0	92	33	1904, Mar. 11	6	39.2	59	57.9	27842	G. D. H.
Plaquemine	30	17.7	91	15.3	1904, Mar. 25, 26	5	51.2	60	30 4	27367	L. B. S.
Springville.	30	26	90	40.9	1904, Mar. 19, 21	5	41.9	60	42.0	27234	L. B. S.
Baton Rouge.	30	28.2	91	11.5	1903, Jan. 19	5	51.5	60	29.5	27305	E. S.
Covington	30	29	90	07.3	1903, Jan. 6	5	27.6	60	41.4	27201	E. S.
Opelousas..	30	33	92	04	1904, Feb. 10, 11	6	22.8	60	20 6	27575	G. D. H.
New Roads	30	41.8	91	27.9	1903, Jan. 28–30	6	00.0	60	47.1	27200	E. S.
Amite	30	44.3	90	28.7	1903, Jan. 8	5	43.4	60	49.9	27173	E. S.
St. Francisville.	30	45.9	91	20.3	1903, Jan. 24, 26	6	00.2	60	50.8	27131	E. S.
Chicot marble q'y.	30	47	92	28	1904, Feb. 27, 28	6	44.9	60	46.7	27027	G. D. H.
Oakdale..........	30	48	92	38	1904, Mar. 1, 2	6	43	60	41.4	27172	G. D. H.
Greensburg	30	49 5	90	42	1903, Jan. 12, 13	5	47 8	60	55.4	27115	E. S.
Franklinton	30	52	90	09.2	1904, Mar. 17, 18	5	33 9	61	04 8	26973	L. B. S.
Clinton..........	30	53 4	91	00 3	1903, Jan. 22	5	50.7	60	53 5	27120	E. S.
Cheneyville	30	59	92	18	1904, Feb. 24	6	38.2	60	58 8	27131	G. D. H.
Marksville.	31	07	92	03	1904, Feb. 25	6	32.7	61	03 2	27188	G. D. H.
Leesville	31	10.7	92	15 1	1904, Jan. 13, 14	7	02.2	61	00.4	27072	L. B. S.
Alexandria.	31	20	92	25.1	1904, Feb. 16, 17	6	38	61	13.4	26982	L. B S
Colfax.......	31	32.2	92	42.1	1904, Feb. 15	6	42.8	61	28.7	26823	L. B. S.
Many......	31	34.4	93	29.4	1904, Jan. 15	7	04 6	61	30.7	26856	L. B. S.
Vidalia...........	31	34.7	91	26.3	1904, Mar. 4, 5	6	03.6	61	38 5	26722	L. B. S.
Natchitoches. ...	31	45.8	93	03 9	1904, Feb. 13	6	44.4	61	39 5	26751	L. B. S.
Harrisonburg....	31	47.2	91	49.4	1904, Mar. 2	6	17.3	61	56.2	26546	L. B. S
St. Joseph	31	56.5	91	14.4	1904, Mar. 7, 8	6	03.6	62	08.2	26437	L. B. S.
Winnfield	31	56.9	92	36.4	1904, Feb. 9	6	48.6	61	53.9	26552	L. B. S.
Coushatta..	32	00.9	93	21.9	1904, Mar. 28	6	57.3	61	51.9	26596	L. B. S.

TABLE I.—*Concluded.*

Station.	Latitude. °	Latitude. ′	Longitude W. of Gr. °	Longitude W. of Gr. ′	Date.	Declination East. °	Declination East. ′	Dip. °	Dip. ′	Hor. Int.	Observer.
Mansfield........	32	02.9	93	41.4	1904, Jan. 18	7	00.6	61	53 4	26582	L. B. S.
Columbia........	32	06.1	92	03.2	1901, Apr. 22, 23	6	19.7	62	08.2	26530	W. W.
Winnsboro........	32	09	91	42.3	1904, Feb. 29	6	12.9	62	16.0	26348	L. B. S.
Tallulah........	32	25.1	91	12.0	1904, Feb. 23, 24	6	00.7	62	33 4	26190	L. B. S.
Rayville........	32	28	91	45	1904, Feb. 25	6	18.9	62	36 3	26166	L. B. S.
Monroe........	32	30.3	92	05.9	1904, Feb. 19, 21, 22	6	26.6	62	33.7	26214	L. B. S.
Shreveport........	32	31.0	93	45 9	1904, Jan. 20–25	6	59.1	62	23.7	26357	L. B. S.
Ruston........	32	32.6	92	37.4	1904, Feb. 4	6	45.0	62	33.2	26157	L. B. S.
Arcadia........	32	32.8	92	55.8	1904, Feb. 3	6	49.8	62	33 2	26204	L. B. S.
Minden........	32	38.4	93	16.7	1904, Jan. 26, 27	7	01.1	62	32 0	26253	L. B. S.
Benton........	32	40	93	43 9	1904, Mar. 30, 31	7	04.6	62	41.6	26120	L. B. S.
Floyd........	32	42.3	91	23.8	1904, Mar. 12, 14	6	14.5	62	58.8	25896	L. B. S.
Farmerville........	32	46	92	23.1	1904, Feb. 6	6	39.9	62	50.3	26051	L. B. S.
Bastrop........	32	46.6	91	54.2	1904, Feb. 26, 27	6	19.7	62	53 5	26053	L. B. S.
Lake Providence..	32	48	91	09.5	1904, Mar. 10	6	04.4	62	58.1	25947	L. B. S.
Homer........	32	48.4	93	03.4	1904, Jan. 29, 30	6	53.7	62	46.7	26056	L. B. S.

TABLE II

Additional Values of the Magnetic Declination Observed Previous to 1901

Chiefly by the Coast and Geodetic Survey and Reduced to Jan. 1, 1904

Station.	Latitude.	Longitude.	Year and Decimal	Magnetic Declination Observed at Date. East.	Jan. 1, 1904, East.	Observer.
	° ′	° ′		° ′	° ′	
S. W. Pass, near Stake I.	28 59	89 23	1872 17	6 05.4	4 59	T. C. Hilgard
Isle Dernière	29 02.0	90 54.2	1853.14	8 19.2	5 45	J. G. Oltmanns
Cubit	29 09.9	89 14.6	1859.95	7 31.8	5 19	"
Pass à Loutre	29 10.9	89 01.4	1859.99	7 30	5 14	"
Osgood Island	29 11.3	89 05 3	1872.18	6 10.7	5 05	T. C. Hilgard
Ft. Livingston (Barataria bay)	29 16.4	89 56.7	1853.2	7 38.4	5 01	J. G. Oltmanns
Magnolia Base, Lower end	29 32 5	89 46 6	1872.05	6 46.8	5 40	T. C. Hilgard
Marsh I. Light Ho.	29 34.8	92 02.2	1886.04	6 53.7	6 22	J. B. Baylor
Morgan City	29 40.2	91.15	1886.38	6 30.1	5 59	"
Barrel key (Chandeleur Sd.)	29 54.3	89 07.9	1857.29	7 36.1	5 12	S. Harris
New Orleans (Fair grounds).	29 59 1	90 04.8	1895.55	5 40.4	5 37	G. R. Putnam
Lake Pontchartrain (E. Base).	30 01.3	90 07.2	1896.25	5 33	5 30	C. C. Yates
Chandeleur L. Ho.	30 03	88 52	1896.1	4 58	4 55	U. S. Engineer
Frenier	30 06.0	90 25.1	1896.23	5 36	5 33	C. C. Yates
Kirsch.	30 10.3	90 25.8	1896.23	5 29	5 26	"
Mermentau	30 12	92 27	1890.31	6 49.4	6 36	J. B. Baylor
Northwest Point	30 14.4	90 21.2	1896.26	5 31	5 28	C. C. Yates
Grand Ecore	31 48	93 07	1872.27	7 52.4	6 46	T. C. Hilgard

SECULAR CHANGE OF THE MAGNETIC DECLINATION IN LOUISIANA BETWEEN 1840 AND 1904

From a consideration of all the available reliable values of the magnetic declination observed over the entire State since 1840, it is found that on January 1, 1904, the compass needle pointed:

3°03′ less east than on Jan. 1, 1840
2 44 " " " " " " 1850
2 15 " " " " " " 1860
1 18 " " " " " " 1870
0 43 " " " " " " 1880
0 16 " " " " " " 1890
0 06 more " " " " " 1900

Thus, for example, if at some undisturbed place, at New Orleans, the needle bore on January 1, 1904, 5°37′ East, then on

Jan.	1,	1840	it	bore	8°	40′	East
"	"	1850	"	"	8	21	"
"	"	1860	"	"	7	52	"
"	"	1870	"	"	6	55	"
"	"	1880	"	"	6	20	"
"	"	1890	"	"	5	53	"
"	"	1900	"	"	5	31	"

These values accord well with those on record for New Orleans at the Coast and Geodetic Survey Office.

It would appear from the examination of the few records of observations available prior to 1840, that about 1830, the needle bore at New Orleans its maximum amount east (about 8¾° E.) and for a period beginning about 100 years prior to 1830 it had steadily been increasing until reaching the maximum in 1830.

From 1830 to about 1898 the easterly bearing of the needle steadily diminsihed until reaching a minimum value of about 5½° E. in 1898; since then the easterly bearing has again been increasing and at a rate of about 1½ minute per year.

DESCRIPTION OF MAGNETIC STATIONS IN LOUISIANA, 1901–4

ABBEVILLE

(Vermillion Parish)

The station is in a pasture belonging to Mr. Légé, which is north of the Eunice branch of the S. P. R. R. and of the railroad station, Abbeville. The station is about 15 feet east of a steep bank, which forms the eastern bank of the Vermillion River. The mark is the tip of the ventilator in the west gable end of a schoolhouse about 200 yards east. This bears 78° 22′ East of true S. The station is marked by two iron pipes set in the azimuth line produced to the west; the first one is eight feet from the station and is two feet long and ¾ inches in diameter. The second one is 14 feet from the station, is 1½ feet long and 1 inch in diameter.

ALEXANDRIA

(Rapides Parish)

The station of 1901 was reoccupied. It is in the national cemetery at Pineville, on the east side of Red River. It is marked by a marble post 6 inches square, set so as to leave 3 inches projecting above ground. This post is 135 feet from the brick fence on the southeast side of the cemetery and 223.8 feet from the brick fence on the northeast side. The top of the well house at the Superintendent's lodge in the southern part of the grounds, bears 46° 27′.0 west of true south. The southwest corner of the brick stable bears 24° 14′.9 west of true south.

ANSE-LA-BUTTE

(St. Martin Parish)

The station is in the center of the oil field between Lafayette and Breaux Bridge, as shown in the forthcoming Louisiana Geological Survey Report.

AMITE

(Tangipahoa Parish)

The station of 1896 is now covered by a shed, so a new station was selected a little north of the old one. It is in the Court-House grounds, 17.5 feet from the east fence and 43.5 feet from the north fence. It is marked by the top of a bottle set in cement. A similar mark was set near the fence on the south side of the grounds, 296.7 feet from the first and bearing 30° 35′.6 west of true south. The Baptist Church spire bears 63° 10′.8 east of true north.

ARCADIA

(Bienville Parish)

(See Pl. XIV, fig. 1)

The station is on the prolongation of the meridian line established by Prof. G. D. Harris of the State Geological Survey. It is 151.1 feet north of the present north monument and 216.7 feet from the northwest corner of the Court-House. The station is

marked by a rough concretionary boulder set flush with the ground and having a cross + to mark the exact point. The spire of the Methodist church bears 63° 21′.8 east of true north.

AVERY'S ISLAND

(*Iberia Parish*)

(See Pl. XV, fig. 1)

Observations were made over the south monument of the meridian line previously established by Prof. G. D. Harris of the State Geological Survey.

BALDWIN

(*St. Mary's Parish*)

The station is marked by a stake driven in a levee along the south side of a ditch. The stake is east of the S. P. R. R. depot and section house and is about 30 feet northwest along the levee from a road running northeast and southwest and across the railroad. The latitude is 29° 49′ 15″.

The mark, a small cupola one half mile distant, bears 72° 06′.2 east of true south.

BASTROP

(*Morehouse Parish*)

(See Pl. XIV, fig. 4)

The station is on the meridian line produced, being 265.4 feet south of the present south monument. It is in the open lot south of the school yard and is marked by a pine post 6 inches square, projecting 2 inches above ground, and having a nail in the top to mark the exact point. The spire of the Episcopal church bears 35° 31′.0 west of true north. The meridian line was established by Prof. G. D. Harris.

BATON ROUGE

(*East Baton Rouge Parish*)

The station of 1896 is no longer available. A new station was therefore selected, about 750 feet south and 350 feet west of the old station, on the grounds of the new State University. It is

south of the east barracks and just west of the main road through the grounds, and is marked by a limestone post 6 by 9½ inches, set with its top even with the surface of the ground. A similar stone, 522½ feet distant, near the south fence of the grounds, marks the south end of a meridian line of which the magnetic station is the north end.

BENTON

(Bossier Parish)

The station is in the vacant lot southwest of the court-house. It is 78.5 feet from the fence to the south and 89.0 feet from the fence to the west. The station is marked by a large sandstone boulder projecting 3 inches above ground and having an x to mark the exact point. The spire of the Presbyterian church bears 31° 9.2 east of true north. Two limestone posts, each 6 by 8 by 30 inches, projecting 4 inches above ground, and having an x to mark the exact point, are set in the court-house yard, and with the magnetic station form a meridian line. The south stone is 147 feet north of the magnetic station and 69.8 feet from the southwest corner of the Court-House. The north stone is 204 feet north of the south monument and is 69.0 feet from the northwest corner of the Court-House.

CAMERON

(Cameron Parish)

(See Pl. XV, fig. 8)

The meridian line established by Prof. G. D. Harris of the State Geological Survey was used. This line is 780 feet long and extends across the garden and lands of Dr. Isaac Bonsel, passing about 7 feet west of his office. The south end is 150 yards northeast of the Court-House. The line is marked by four marble posts 4 by 5 by 30 inches, set in concrete. The monument S is ten feet from the road fence, 3 feet from a Bois d' arc hedge, 32.7 feet from the southeast corner and 26.5 feet from the southwest corner of the doctor's office.

CHENEYVILLE

(*Rapides Parish*)

The station is in the fields southwest of the T. P. Railroad depot. It is about 110 feet west of a narrow road running north and south and 40 feet west of the intersection of two paths, which with the narrow road surround a negro hut and barn on three sides. The station is marked by a stake. The Baptist church spire bears 6° 49′ east of true north.

CLINTON

(*East Feliciana Parish*)

The station is inside the race track at the fair grounds, about a mile north of the Court-House. A south meridian mark was placed 195 feet due south of the magnetic station and about 2 feet from the inner fence of the race track. It consists of a 4-inch terra-cotta pipe set in cement. The pipe is filled with cement and the neck of a bottle marks the center. The north end of the meridian line was marked in a similar manner, and is also just inside the inner fence of the race track. The two marks are about 800 feet apart, and are to the east of the centre of the space inclosed by the race track.

COLFAX

(*Grant Parish*)

The station is on the left or north bank of Red River, about one fourth of a mile almost due south of the court-house. It is 110.7 feet from the northeast corner of a lot owned by J. H. McNeeley; 119.5 feet from the northwest corner of a lot belonging to Edd Evans, and 128.5 feet from the southwest corner of the lot of Mrs. Calhoun, these last two lots being on opposite corners of a street running northeasterly from the river and at its intersection with the street running along the river. The station is marked by a sandstone boulder set flush with the ground and having a lead plug to mark the exact point. A meridian line was marked by a similar stone, set 267.5 feet to the north and 10.8 feet from the west fence of Dr. W. J. Robert's

yard. The spire of the Catholic church bears 16°31′.6 west of true north. The court-house spire bears 3° 01′.9 west of true north.

COLUMBIA

(Caldwell Parish)

The station is southwest of town on a range of hills that run north and south. It is in the cemetery on the hill opposite the one on which the graves are located. It is marked by a stone post 6 inches square, set so as to leave 3 inches projecting above the surface of the ground. The exact location can be had from the authorities at the court-house. The mark or range used was the flagstaff on the public schoolhouse on Boatner street and bears 45°11′.2 east of true north.

CONVENT

(St. James' Parish)

The station is in the southwest corner of a lot owned by Henry Himel, 31 feet from the west fence and 49 feet from the south fence. It is marked with a 4-inch terra-cotta pipe set in cement. The pipe is filled with cement and the center marked with the neck of a bottle. This is the south end of a meridian line 437½ feet long. The north end is similarly marked and is near the north fence of the lot owned by Lewis Le Bourgeois.

CÔTE BLANCHE

(Iberia Parish)

The Station is in the center of the Island in the locality known as "Oak Hill," perhaps 150 feet west-ward from the former U. S. C. & G. S. triangulation monument now destroyed. See Côte Blanche, La. Geol. Surv. Rept. 1905.

COUSHATTA

(Red River Parish)

The Station is southeast of the Court-House and is about 9 feet from the west edge of the street running south past the

Court-House yard. It is marked by a limestone post 6 by 6 by 36 inches, projecting 4 inches above ground and having an x to mark the exact point. This is the south monument of a meridian line 367.9 feet long, the north end of which is marked in a similar manner. This north monument is 75.7 feet from the northeast corner of the Court-House, 44.0 feet from the east fence and 7.7 feet from the north fence of the Court-House yard.

COVINGTON

(*St. Tammany Parish*)

(See Pl. XV, fig. 7)

Observations were made over the south stone of the meridian line established by the State Geologist. The line is described in his report as follows: General location: On land of Judge James L. Thompson, about one-third mile northward of the cemetery, near the first slight angle or deflection to the westward of the Holmesville road; the old Massay Baker grant. Monuments: N is a marble post 6 by 8 by 30 inches, set in concrete and projecting two or three inches above the surface of the ground. About 7 feet due north is a granite marker 5 by 12 by 13 inches, likewise set in concrete. These are near the edge of a thin pine woods on the east edge of an old rice field. A wire fence passes between the two. S is of marble and similarly set, 1,203 feet south of N. The granite marker is 6.2 feet to the south. These are close to the Holmesville road, just over the fence.

CROWLEY

(*Acadia Parish*)

(See Pl. XVI, fig. 1)

The station occupied is the south one of three markers showing a meridian line across the school grounds ⅓ mile north of Crowley P. O. Due south from this marker it is 53 feet to the school ground fence. North of this marker, 233.7 feet is the middle marker, the latter being 33.65 feet from the east corner of the school building. To the north still farther, 253.6 feet is marker number three and 161.5 feet due north of the same

the meridian line crosses the front fence of the grounds, 30 feet from the north corner of the same.

The markers were constructed of single lengths of 6 inch tile filled with concrete and sunk length-wise in a mass of concrete some 2 feet in diameter. The tile projects but little above the general average of the ground.

DONALDSONVILLE

(*Ascension Parish*)

The station of 1896 is no longer available, so a new one was located in the lot just north of the old station, on the east side of Church street, near the entrance to the Catholic cemetery. It is 27 feet from the street fence and 28½ feet from the south fence of the lot. A meridian line was marked by two 3-inch terra-cotta pipes set in cement with the neck of a bottle in the center of each. One is 314 feet due south of the magnetic station near the cemetery fence. The other is 54½ feet due north of the station close to the east fence of Church street. From the magnetic station the cross on the tomb of Joseph Landry bears 24° 49′.1 west of true south, the spire of the old convent bears 22° 24′.4 west of true north, and the spire of the new church bears 17° 26′.1 east of true north.

EDGARD

(*St. John Baptist Parish*)

The station is in the northeast corner of the Court-House grounds, 62.7 feet from the north fence and 48.7 feet from the east fence. It is marked by a 4-inch terra-cotta pipe set in cement with the neck of a bottle in the center. A mark was cut on the brick wall forming the base of an iron fence, about 560 feet due north of the station, thus defining the true meridian. The following true bearings were determined: South finial on large store near levee 22° 00′.8 west of north. North finial on same store 19° 45′.8 west of north. Catholic Church spire 48° 58′.7 east of true north.

EVANGELINE

(*Acadia Parish*)

The station is near the southeast corner S. 45, T. 9, S. R. 2, W. It is just north of a small brook flowing through the southern portion of the oil field, and is 800 feet west of the bridge on the north and south road, passing on section line through the oil field. It is marked by a wooden plug driven in the ground. The latitude of the station is 30° 16′. See Bulletin of Geol. Surv. Rept. 1905 devoted to Oil.

FARMERVILLE

(*Union Parish*)

The station is about one-fourth of a mile southeast of the Court-House in an open lot owned by J. M. Smith, which is on the east side of the road to Cox's Ferry. The Station is 76.6 feet from the fence to the east ; 73.7 feet from the fence to the south ; and 115.7 feet from a lone pine tree near the edge of the road. The station is marked by a brown sandstone boulder, set flush with the ground and having a cross + to mark the precise point. Two similar stones set directly north of the magnetic station mark the meridian, the south stone being 410 feet and the north stone 850 feet north of the magnetic station. From the magnetic station the southwest corner of the jail bears 10° 58′.8 west of true north. The east gable of the K. of P. hall bears 6° 25′ .2 west of true north.

FLOYD

(*West Carroll Parish*)

The magnetic station is in the open lot south of the Court-House and 37.6 feet north of a certain fence. It is marked by a six inch sewer pipe filled with mortar and imbedded in a mass of mortar. A large spike set in the mortar marks the exact point. The steeple of the Methodist church bears 22° 55′ .2 west of true south.

Two monuments similar to the above, with the magnetic station, mark the meridian line. The south monument is 174.7 feet north of the magnetic station, 158.7 feet southwest of the

southwest corner of the Court-House, 8.8 feet north of the south fence and 30.8 feet east of the west fence of the Court-House yard. The north monument is 269.6 feet north of the south monument, 132.2 feet northwest of the northwest corner of the Court-House, 7.8 feet south of the north fence and 33.1 feet east of the west fence of the Court-House yard.

FRANKLIN

(St. Mary Parish)

(Pl. XV, fig. 2)

A meridian line had been established at this place in 1902 by Prof. G. D. Harris, of the State Geological Survey. It is in a pasture across Bayou Teche, opposite the wharves. Part of this pasture is now used as a race track. The meridian line is marked by two sandstone posts about 8 inches square with a hole filled with lead in the center of the top of each. The south stone is about 160 feet from the bayou and close to a fence. The north stone is 554½ feet from the south stone and about 100 feet north and somewhat more than 100 feet east of the inner fence of the race track. The north stone marks the magnetic station. From it the flag pole on the jail bears 37° 10′.5 west of true south.

FRANKLIN

(St. Mary's Parish)

The station of 1903 was reoccupied. It is the north stone of a meridian line established in 1902 by Prof. G. D. Harris of the State Geological Survey. This line is 554.5 feet long and in a pasture across Bayou Teche, opposite the wharves. Part of this pasture is now used as a race track. The meridian line is marked by two sandstone posts about 8 inches square with a hole filled with lead in the center of the top of each. The south stone is about 100 feet from the bayou and close to a fence; the north stone is about 100 feet north and somewhat more than 100 feet east of the inner fence of the race track. From this stone the flag pole on the jail bears 37° 10′.8 west of true south. The west edge of the city stand pipe bears 88° 25′.6 west of true south.

FRANKLINTON

(*Washington Parish*)

The station is on the grounds of the Franklinton Collegiate Institute, in the northwestern part of town. It is southeast of the college building and east of the dormitory. The station is 33.2 feet east of a sweet gum tree, 51.0 feet from the southeast fence and 59.7 feet from the northeast fence of the college grounds. It is marked by a large sandstone boulder, projecting about 2 inches above ground and having a cross to mark the exact point. The spire of the Methodist church bears 51° 26′.4 east of true south. The meridian line is marked by a second sandstone boulder set about 635 feet north of the magnetic station on the property of Mr. Robert Babington. It is about 25 feet from a large oak tree and 15 feet from the corner of the rail fence enclosing the field to the west.

GRANDE CÔTE, WEEKS ISLAND, SALT MINE

(*Iberia Parish*)

The station is a little north of west from Weeks' residence, in the northwestern part of the island. It is south of a road leading past the residence to a landing on the south bank of Weeks Bayou. The latitude of the station is 29° 50′ 15″.

GREENSBURG

(*St. Helena Parish*)

The station is on the grounds of the Norvilla Collegiate Institute, west of the south end of the building. It is 150 feet south of the north line of the lot and 30 feet east of the west line. It is marked by the neck of a bottle set in cement, and is the north end of a meridian line 488 feet long. The south end is similarly marked.

GRETNA

(*Jefferson Parish*)

The station is in the baseball grounds about six blocks southeast of the Court-House, being 59 feet from the southwest fence and 38.8 feet from the southeast fence. It is marked by a post

of Georgia marble, 6 inches square, set flush with the ground and having a cross + to mark the center. A similar post 291.3 feet to the north marks the meridian line. This north stone is 5 feet from the grandstand to the northeast and 22.6 feet from the grandstand to the northwest. The steeple of the "Old Colored" Baptist church bears 51° 28'.5 west of true north. The east edge of the water tower at the Union Iron Works (in New Orleans) bears 16° 57'.9 west of true north.

HAHNVILLE

(*St. Charles Parish*)

The station is on the Court-House grounds in the rear of the jail inclosure. Two 6 inch fire-clay pipes were set in cement with the neck of a bottle in the centre of each to mark the true meridian passing through the magnetic station. One is near the north fence and 112 feet from the northwest corner of the grounds. The other is in the southwest corner of the grounds, 40 feet from the west fence and 25 feet from the south fence. The magnetic station is 202.8 feet from the north mark and 123.6 feet from the south mark and exactly in the line between them.

HARRISONBURG

(*Catahoula Parish*)

The station is in the meridian line established by Prof. G. D. Harris upon the property owned by J. E. Griffin. It is 125.7 feet north of "S" stone in the meridian line. The magnetic station is marked by a sandstone boulder set flush with the ground and having a cross + to mark the exact point.

HOMER

(*Claiborne Parish*)

The station is in the parish fair grounds south of the city. It is southeast of the race track in an open space covered with small pine stumps and is 61.3 feet from the south fence 58.8 feet from a large pine tree north of east; and 23.5 feet from a second pine

tree to the northwest. The station is marked by a large tile, filled with cement and having the neck of a bottle in the center. A similar tile set 875 feet north marks the meridian line. This north monument is near the bank of a creek and is 17.4 feet east of a wild cherry tree and 100 feet from the southwest corner of the largest fair building. The spire of the colored M. E. church bears 21°55′.4 west of true north. The spire of the Court-House bears 11°33′.0 east of true north.

HOUMA

(*Terrebonne Parish*)

(See Pl. XV, fig. 4)

A meridian line had been established at this place in 1902 by Prof. G. D. Harris, of the State Geological Survey. It is in the lot back of the Catholic Cemetery, between Grinage and Goode streets. It is marked by three marble posts 6 inches square, set in cement. The north stone is very near the south fence of cemetery and 145 feet from the west fence of the lot. The south stone is about 70 feet north of a ditch at the south end of the lot. The middle stone is 267 feet from the south stone and 242½ feet from the north stone. The magnetic station was over the south meridian mark. The finial of the cupola of the convent bears 85° 27′.2 east of true south.

JENNINGS

(*Calcasieu Parish*)

(See Pl. XVI, fig. 2)

The station is 40 feet south of the middle meridian monument in the meridian line, previously established by Prof. G. D. Harris. This line is one mile east of the town, and is marked by 6 inch sewer pipes set into a mass of cement. The observations were made at the north base of the south levee of the McFarlan canal.

LAFAYETTE

(*Lafayette Parish*)

(Pl. XVI, fig. 3)

The station is 390 feet due south of the south monument of

the meridian line, previously established by Prof. G. D. Harris, back of the grounds of the Industrial School.

LAKE CHARLES

(Calcasieu Parish)

(Pl. XV, fig. 6)

Observations were made over the north monument of the meridian line established by Prof. G. D. Harris on the grounds of Lake Charles college. This stone is about 7 feet inside the north fence. The south stone is near the south fence of the college grounds which are nearly bisected by the meridian line. Both stones are marble posts 4 inches square embedded in a solid mass of concrete. The exact point is marked by a small copper nail in the center of a hole filled with lead. The east gable of the Baptist State Orphanage bears 49°22′ .1 west of true south.

LAKE PROVIDENCE

(East Carroll Parish)

The station is in the lot owned by Miss Ethel Montgomery and south of the Court-House yard. It is 27.6 feet from the fence to the northwest, 37.3 feet from the fence to the southwest and 74.8 feet from the west corner of a very small one-story and one room brick building. The magnetic station is marked by a block of cement 6 by 8 by 14 inches set flush with the ground and having an x to mark the exact point. The spire of the African Methodist church bears 64° 51′ .2 west of true north. The meridian line is marked by the magnetic station and two stones, each 16 by 16 by 12 inches set flush with the ground and having a large hole to mark the exact point. These two stones are near the fences of the Court-House yard, the south stone being 193.7 feet north of the magnetic station and 7 feet inside the southwest fence of the Court-House yard, and the north stone being 284.7 feet north of the south stone, 20 feet inside the northeast fence of the Court-House yard and almost in line with the southeast fence around the jail.

LEESVILLE

(*Vernon Parish*)

The station is in the garden of Mr. Elzie Stokes, parish surveyor, and about one and a half miles northeast of Leesville. It is 22.7 feet from the east fence, 48.4 feet from the north fence and 70.5 feet from the south fence of the garden. The station is marked by a copper nail in the end of a pine post, set flush with the ground. The east gable of Mr. M. Smart's house bears 86° 15′ .2 west of true south. The west gable of M. J. Mitchell's barn bears 73° 24′ .4 east of true south.

MANSFIELD

(*De Soto Parish*)

The magnetic station is 99.8 feet from the south stone of a meridian line established by Prof. G. D. Harris and is in the direction of the azimuth mark, the steeple of the Seventh Day Adventist church. The station is also 100.8 feet from the wire fence to the south and 85 feet to the corner of the wire fence west of south. It is marked by a pine stake driven almost flush with the ground. The steeple of the Seventh-Day Adventist church bears 18° 31′.4 west of true north. The cross on the Episcopal church bears 58° 23′.6 west of true north.

MANY

(*Sabine Parish*)

The station is the south stone of the meridian line established by Prof. G. D. Harris. It is in the lot west of E. C. Dillon's house, 18.5 feet north of a wild crab-apple tree, 40 feet from the fence on the north side of the road and 82.3 feet from the fence on the west. The station is marked by a calcareous lignitic boulder set flush with the ground and having a cross + to mark the exact point. A stone 900 feet north and near the edge of the pine woods marks the meridian. The Court-House spire bears 76° 09′.5 east of true south.

MARBLE QUARRY

(*St. Landry Parish*)

The station is at an abandoned quarry now overgrown with pine forest in Sec. 34, T. 3 S. R. I. W. It is southwest of three old kilns and the camp and is southeast of the lime quarry. Caney branch is north and east of the station. Two stakes were set 340 feet apart and observations made over the north stake. The azimuth of this line is 346° 28′.5 west of true south.

See this locality as mapped in La. Geol. Survey Report of 1905.

MARKSVILLE

(*Avoyelles Parish*)

(See Pl. XVI, fig. 4)

The station is 22 feet north of the south monument of the meridian line established by Prof. G. D. Harris in 1903. This line is on the public Poor Farm. The monuments are rectangular stone posts sunk in the ground about 2.5 feet and projecting above the general surface of the ground about 4 inches. The meridian line is indicated by ⅓ inch holes drilled in the tops of the stone posts.

MINDEN

(*Webster Parish*)

The station is on the lot of the city pest house which if about one and one-fourth miles northwest of the city. It is about 80 yards north and west of the pest house and 76.7 feet from an oak tree east of north. The station is marked by a large tile filled with cement and having the neck of a bottle at the center. Two other similar monuments were set to mark the meridian line, the south monument being 268.8 feet south of the magnetic station and about 6 feet from the south fence, while the north monument is 179.4 feet north of the magnetic station and about 18 feet from the road. The north gable of Mrs. Delphi Brown's house bears 49° 06′.7 west of true south.

MONROE

(*Ouachita Parish*)

The station is in a pasture belonging to Mrs. Genie Layton and is about three-fourths of a mile south of the Court-House. It is 60 feet from the east bank of the Ouachita River, 35 feet from a deep gully to the east and 75 feet from the fence to the south (the present line of the city limits). The station is marked by a Bedford limestone post 6 by 8 inches, projecting 4 inches above ground and having a small hole to mark the precise point. The northeast corner of the new brick cotton mill bears 39° 16′.5 east of true south. The spire of the Colored Baptist church bears 5° 29′.1 east of true south. A similar monument, set 558.5 feet north of the magnetic station and near the fence along the road to Columbia, marks the meridian line.

NAPOLEONVILLE

(*Assumption Parish*)

The station is on the property of John B. Foley, just outside the town limits, southeast of the town on the road running just inside the levee along Bayou La Fourche. The station is on the lawn about half way between the road fence and the house, and about 18 feet north of the driveway. Two marble posts 5 inches square set in cement and projecting about 2 inches above the surface of the ground mark the true meridian passing through the magnetic station. One stone is 261.4 feet north of the station near the road-fence; the other is 141.1 south of station near a line fence.

NATCHITOCHES

(*Natchitoches Parish*)

The station is in the meridian line established by Prof. G. D. Harris upon the Normal School grounds. It is 407.8 feet north of the present south meridian monument, which is about 25 feet south of the east and west road through the woods, and is 244.3 feet south of the present north meridian monument which is about 4 feet inside the northern line fence. The magnetic sta-

tion is 13.5 feet from a small cedar tree north of west, 60.5 feet from the northwest corner and 113 feet from the southeast corner of the poultry yard. It is marked by a brown sandstone boulder, set flush with the ground and having a cross + to mark the exact point. The south gable of J. H. Williams' house bears 44°43'.8 east of true north.

NEW IBERIA

(Iberia Parish)

The station is southwest of the New Iberia Baseball Park, northwest of a ditch running by the south corner of the baseball park, and south of a pond and road leading to the northeast. The station is north of a fence running northwest and southeast. The Catholic church spire bears 87°05'.5 east of true south.

NEW ORLEANS

(Orleans Parish)

Observations were made at Audubon Place. The station was not marked.

NEW ROADS

(Pointe Coupee Parish)

The station is in the yard adjoining the residence of Dr. A. P. Fillostre, about one-third of a mile west of the Court-House. It is on the lawn to the north and west of the house, and is marked by a 4-inch terra-cotta pipe in cement. The pipe is filled with cement and the center marked with the neck of a bottle. It is 19 feet from the north fence and 24½ feet west of the fence around the house. A similar mark was placed 403 feet due south of the magnetic station and close to the front fence, thus defining the true meridian.

OAKDALE

(Calcasieu Parish)

(Pl. XVI, fig. 5)

The station is in a clearing one-sixth of a mile almost due east of Oakdale. It is north of the road to Oakdale from Chicot and is

west of an abandoned wooden house. The station is marked by a fat pine stake, 1.2 feet fong, and 0.3 feet in diameter, driven nearly flush with the surface. The north edge of a chimney on a house to the west bears 79°31′ .8 west of true south.

OPELOUSAS

(*St. Landry Parish*)

(See Pl. XV, fig. 3)

The station is 18 feet south and 1.6 inches east of the south monument of the meridian line. The north monument was used as a target, being distant 400 feet. This meridian line is in the public cemetery about one-half mile east of the Court-House.

PLAQUEMINE

(*Iberville Parish*)

The station is about one-third of a mile south of town in Mr. Edward Desobry's pasture. It is about 500 feet west of Mr. Desobry's house, 82.6 feet from the west corner of a large shed, 21 feet from the middle of a large ditch to the southeast and 42 feet from the middle of a second large ditch to the southwest. The station is marked by a Bedford limestone post, 6 inches square, set flush with the ground and having an x to mark the exact point. The Catholic church spire bears 2° 21′.0 west of true north. A second limestone post marks the meridian. It is 652.5 feet north of the magnetic station, 13.5 feet inside the fence along the road and 99.4 feet southwest from the south gate-post at the gate of the lane leading to the Desobry house.

POINT À LA HACHE

(*Plaquemines Parish*)

The station is in the open lot between the Court-House and the Mississippi river. It is 147 feet from the south post of the gate to the Court-House yard and 48 feet from the west corner of a house owned by John Johnson. The station is marked by the neck of a bottle set in cement. The north end of the meridian line, of which the magnetic station is the south end, is marked

in a similar manner and is 309.4 feet from the south end and is near the fence northwest of the Court-House. The east corner of the Court-House bears 22° 43'.1 east of true north. The highest point of the sugar mill on Magnolia plantation bears 26° 42'.1 east of true south.

RAYVILLE

(Richland Parish)

(See Pl. XIV, fig. 5)

The station is on the meridian line produced, at a point 145 feet north of the north monument. It is marked by a cypress stake projecting about one inch above ground. The meridian line was established by Prof. G. D. Harris and lies between the jail and Court-House. It crosses the V. S. & P. R. R. and traverses a woody swamp to the north.

RUSTON

(Lincoln Parish)

(See Pl. XIV, fig. 2)

The station is on the meridian line established by Prof. G. D. Harris on the grounds of the State Industrial College, in 1902. It is 55 feet north of the south monument and is marked by a round hard pine stake driven flush with the ground. The spire of the Methodist church bears 58° 31'.8 east of true north.

ST. BERNARD

(St. Bernard Parish)

The station is in the pasture lot owned by C. D. Armstrong and is just north of Armstrong's quarters. It is 198.8 feet from the south fence, 58.7 feet from the west fence and 116.8 feet from the east fence. The station is marked by a nail in the end of a cedar stub driven flush with the ground. The flag pole on the Court-House bears 59° 52'.2 west of true south. The south edge of the smoke stack at Creedmore sugar factory bears 68° 29'.9 east of true south. A meridian line is marked by two

posts of Georgia marble, 6 inches square, projecting 4 inches. The north monument is 340.9 feet north and the south monument is 167.5 feet south of the magnetic station.

ST. FRANCISVILLE

(*West Feliciana Parish*)

The station is about three-fourths of a mile east of the Court-House, on the Pecan Grove plantation belonging to Judge W. W. Leake. It is on the edge of a field in front of the house, near a gully where the land is not likely to be plowed, 42 feet southwest of a cedar and about 200 feet from the fence on the east side of the field. It is marked with a 4-inch terra-cotta pipe set in cement. The pipe is filled with cement and the center marked by the neck of a bottle. A similar mark was placed in the fence line, 479 feet due south, thus defining the true meridian. The mark used was the gable of an old mill, which bears 16° 01′.9 west of true south.

ST. JOSEPH

(*Tensas Parish*)

The station is in the public square in the southern part of the city. It is about 500 feet southeast of the Court-House and on the line of the row of trees on the southwest side of the square. The station is 138.1 feet from the west corner of the Masonic Hall and 61.3 feet from the fence on the opposite side of the street. It is also 17.4 feet southeast of a box elder and 33.0 feet northwest of a second box elder, these two trees and the station being in nearly the same straight line. The magnetic station is the southern extremity of a meridian line 200.6 feet long, the north monument of which is on the line of the row of trees on the northeast side of the public square. This north stone is 19.2 feet southeast of a box elder and 31.4 feet northwest of a maple, the two trees and the north stone being in nearly the same straight line. Both north and south stones are limestone boulders set flush with the ground and having a cross to mark the exact point. The steeple of the public school building bears 33° 18′.8 west of true north.

ST. MARTINSVILLE

(St. Martin Parish)

(See Pl. XV, fig. 5)

The station is 60 feet north of the south monument of the meridian line established by Prof. G. D. Harris in front of the Catholic Church. The middle monument has been destroyed.

SHREVEPORT

(Caddo Parish)

The station is in the northeastern part of the space inside the Caddo Downs race track, which is about three miles southwest of the Court-House. The inner fence about the race track is distant from the station 38.1 feet, measuring due north, and 34.4 feet, measuring in the direction of the Mulkaupt house. There is a small pear orchard about 15 rods north and west of the station and across the race track. The station is marked by a Bedford limestone post 5 inches square, projecting 5 inches above the general surface, and having a hole filled with lead to mark the center. Two other similar stones mark the meridian; the south stone being 600 feet south of the magnetic station and 6 feet inside the inner fence of the race track, while the north stone is 940 feet north of the magnetic station and is 6 feet inside the high board fence surrounding the race track grounds. The spire of the Jewella Christian church bears 76° 59′.4 west of true south.

Declination observations were also made at the south end of the City Engineer's range line in the southern part of Shreveport. The cupola of Mr. Walter Jacob's barn bears 17° 41′.6 west of true north.

SPRINGVILLE

(Livingston Parish)

The magnetic station is southwest of the Court-House near the southern edge of the Court-House ground. It is 135.7 feet almost south from the southwest corner of the fence around the Court-House and 111.3 feet east of the east fence of Mr. L. D. Allen's

yard. The station is marked by a large spike in the end of a pine post, 6 inches in diameter and projecting 4 inches above ground. The southeast corner of the jail bears 33° 51′ .2 east of true north. The north end of a meridian line 246 feet long is marked in the same manner as the magnetic station. This north monument is just inside the west fence enclosing the Court-House and is 59.1 feet from the northwest corner of the north wing of the Court-House.

TALLULAH

(*Madison Parish*)

The station is in the southeastern part of the Parish Farm and about three-fourths of a mile south of Tallulah. It is 31 feet from the fence along the west edge of the road by the bayou and 23.7 feet from a fence to the southwest. The station is marked by the neck of a bottle imbedded in a six inch tile filled with cement and surrounded by a mass of concrete. A similar monument 252.5 feet north marks the meridian line. This north monument is north of a small peach orchard, 63.7 feet from the northwest corner of a small house and 54.5 feet from the southwest corner of a small fenced lot. The south gable of the "Frisco" section house bears 4° 37′ .6 east of true north.

THIBODAUX

(*La Fourche Parish*)

The station is on the north side of Bayou La Fourche in the lot just west of the house of Judge Beattie. This house is opposite the bridge from Thibodaux and near the Texas and Pacific depot. A meridian line was established at this place in 1902 by Prof. G. D. Harris, of the State Geological Survey. It is marked by three marble posts, 6 inches square, set in cement. The south stone is on the slope of the levee. The next one is across the road from the levee, just inside the fence inclosing Judge Beattie's land. The north stone is close to a line fence and about 700 feet from the south stone. The magnetic station is 129.1 feet due south of the north stone.

VIDALIA

(*Concordia Parish*)

The magnetic station is in the yard northwest of the jail. It is 30.0 feet from the fence around the Court-House yard, 87.0 feet from the fence in the rear of the jail, and 25.6 feet from the center of a large monument lettered U. S. C. S. 1878. The station is marked by a limestone post 6 by 8 by 26 inches projecting 3 inches above ground and having a cross to mark the exact point. The spire of the Baptist church in Natchez bears 77° 04′ .3 east of true south. The south end of a meridian line 239.8 feet long is marked in the same manner as the magnetic station. This monument is 52.5 feet from the west corner of the Court-House and 16.0 feet from the north corner of the Parish office building.

WINNFIELD

(*Winn Parish*)

The station is in the street two blocks west and a little more than two blocks north of the Court-House, and is near the east edge of a small gulley. It is 91.3 feet from the northwest corner of the lot owned by J. G. Teagle, and 76 feet almost due north of a large oak tree. The station is marked by a large "Marble Quarry" boulder, projecting slightly above ground and having a hole filled with lead to mark the precise point. The Court-House spire bears 43° 48′ .6 east of true south. The schoolhouse tower bears 3° 24′ .3 west of true south. Two similar boulders with the magnetic station, mark the meridian line. One is approximately 1100 feet south of the magnetic station and the other 1700 feet; both are in the street.

WINNSBORO

(*Franklin Parish*)

(Pl. XIV, fig. 6)

The station is in the meridian line established by Prof. G. D. Harris across the Court House yard. It is 47.54 feet due north of the monument "N" and is marked by an oak post two by four inches, projecting one inch above ground and having a nail driven in the end to mark the exact point. The east gable of Mrs. R. V. Clarke's house bears 46° 33′ .0 west of true south.

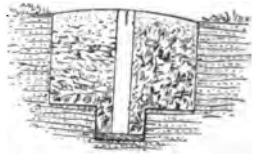
LOCATION OF MERIDIAN LINES*

EXPLANATION OF PLATE XIV

* Plates XIV and XV were published in our report of 1902 as Pls. XL and XLI. It has been thought best, however, to bring all matter relating to magnetic work together in this Bulletin.

EXPLANATION OF PLATE XIV

7



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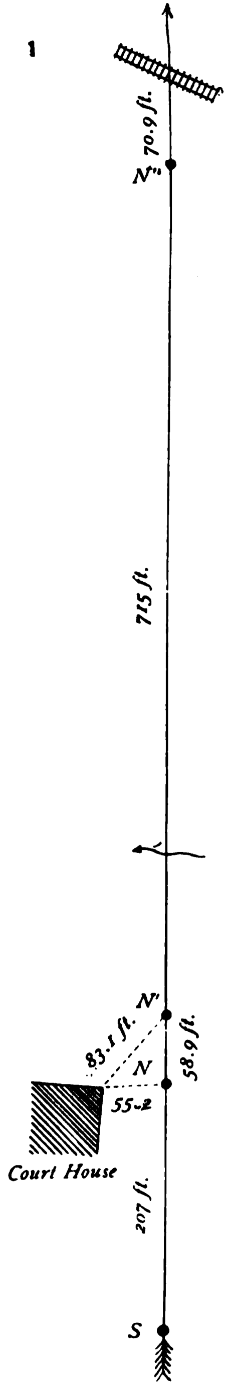
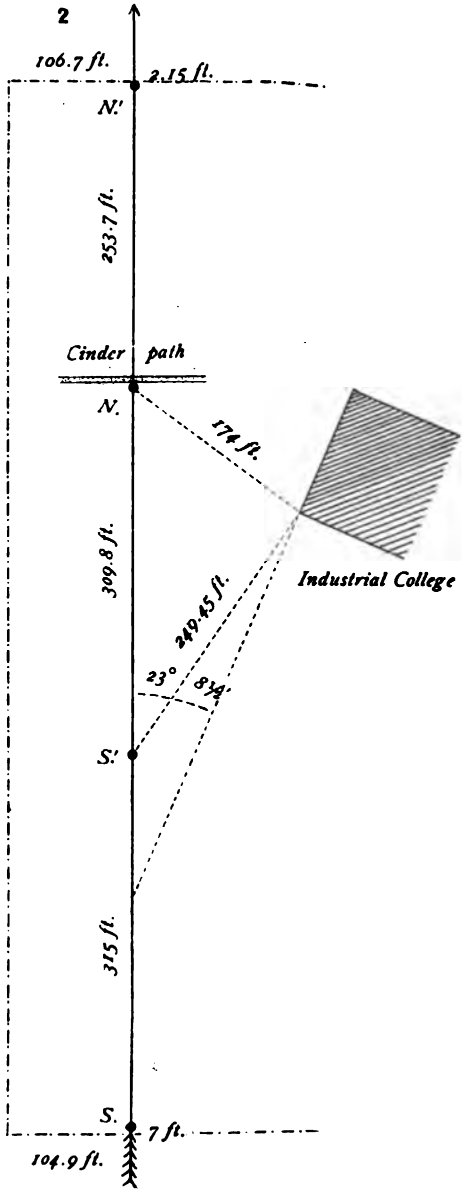
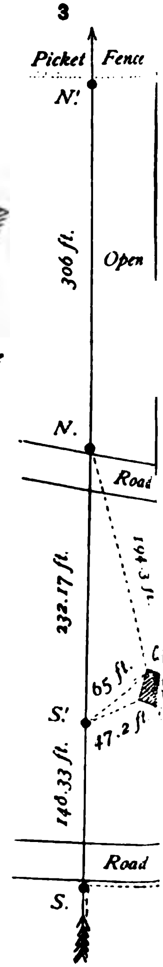

70.9 ft.
N''
715 ft.
N'
83.1 ft.
58.9 ft.
N
55.2
Court House
207 ft.
S

2


106.7 ft.
2.15 ft.
N'
253.7 ft.
Cinder path
N.
174 ft.
Industrial College
309.8 ft.
249.45 ft.
23°
S'
315 ft.
S.
7 ft.
104.9 ft.

3


Picket Fence
N'
306 ft.
Open
N.
Road
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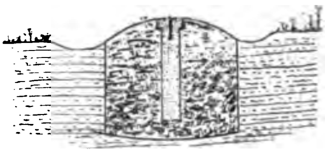
S'
65 ft.
47.2 ft.
148.33 ft.
Road
S.

3



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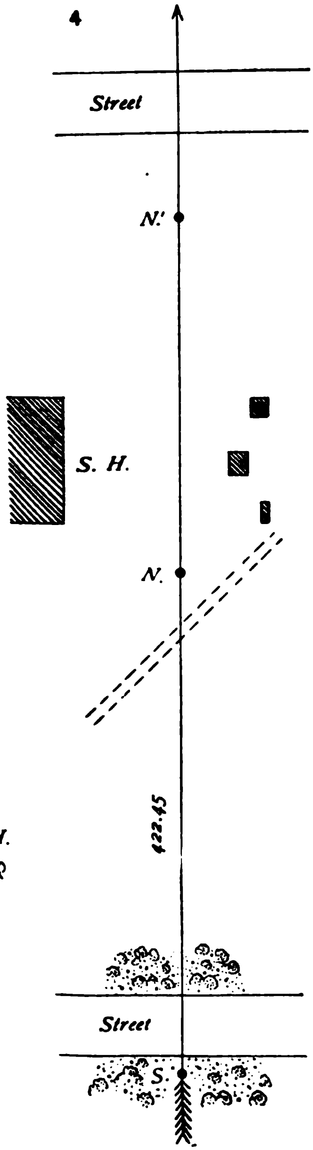
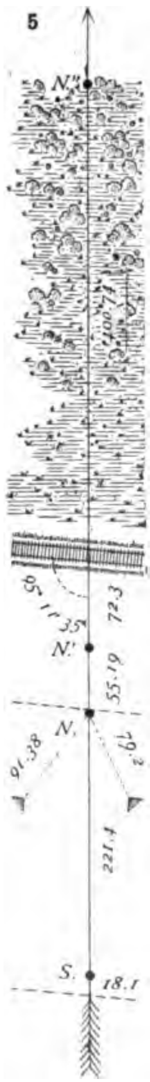

Street
N.'
S. H.
N.
422.45
Street
S.

5


N.''
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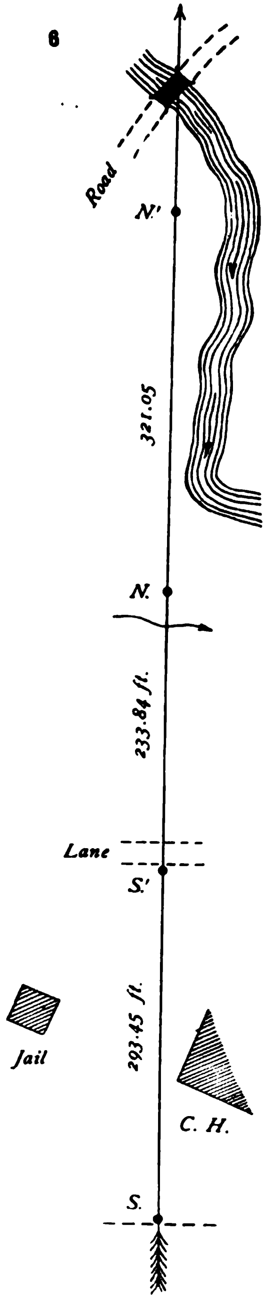
72.3
35
N.'
55.19
N.
91.38
221.4
S.
18.1

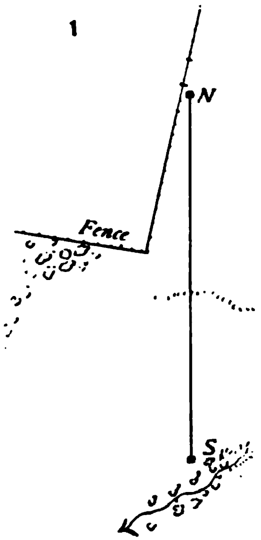
6


Road
N.'
321.05
N.
233.84 ft.
Lane
S.'
293.45 ft.
Jail
C. H.
S.

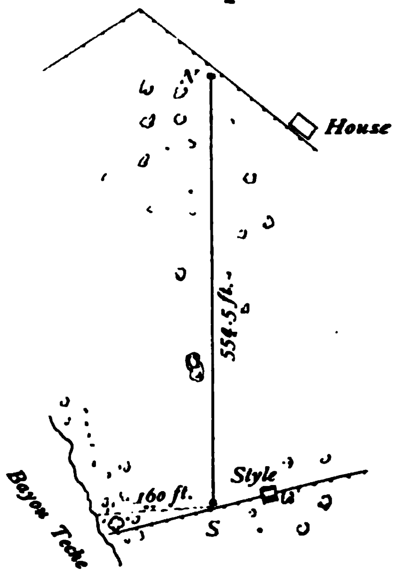
EXPLANATION OF PLATE XV

EXPLANATION OF PLATE XV

1

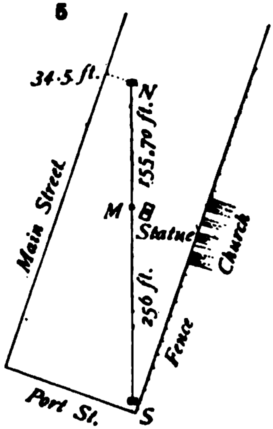

N
Fence
S

2

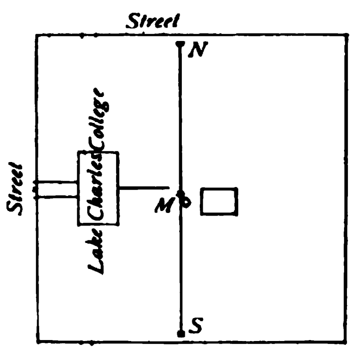

N
House
554.5 ft.
Style
160 ft.
S
Bayou Teche

7

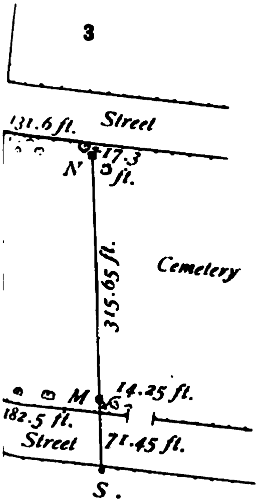
5


34.5 ft.
N
155.70 ft. N
M
Statue
Church
256 ft.
Main Street
Fence
Port St.
S

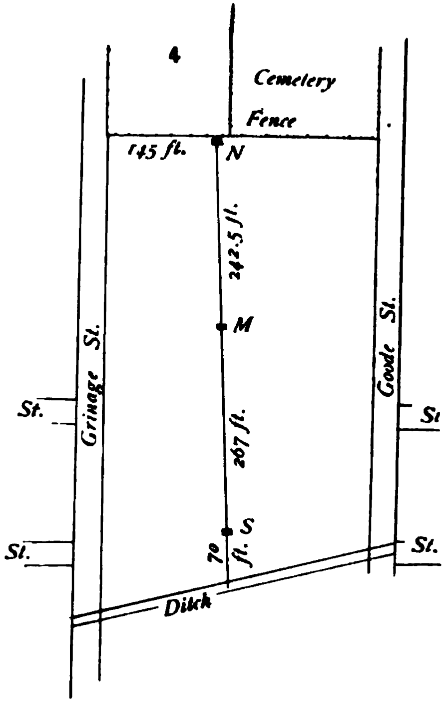
6

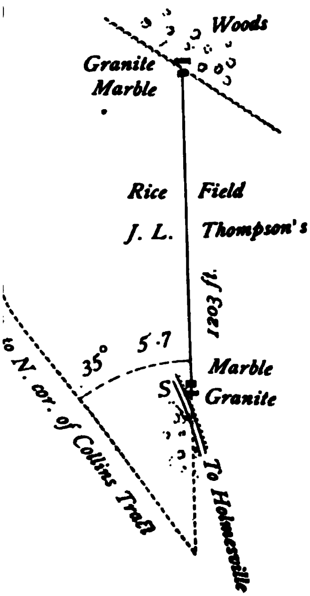

Street
N
Street
Lake Charles College
M
S

3

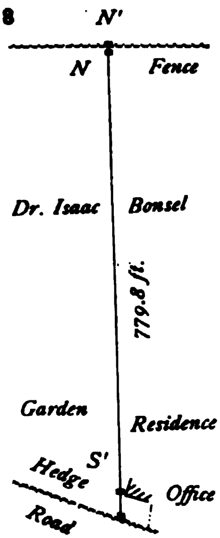

131.6 ft.
Street
17.3 ft.
N
315.65 ft.
Cemetery
M
14.25 ft.
182.5 ft.
Street
71.45 ft.
S

4


Cemetery
Fence
145 ft.
N
242.5 ft.
M
Grinage St.
Goode St.
St.
St
267 ft.
S
70 ft.
St.
St.
Ditch

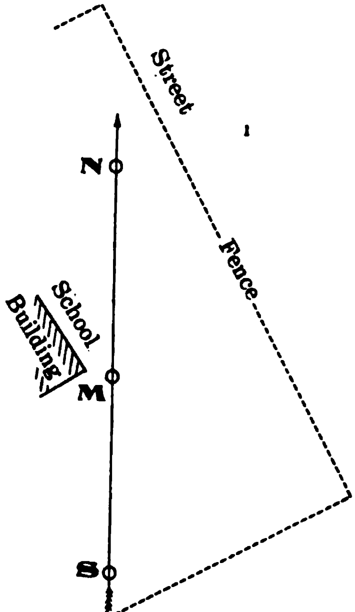

Woods
Granite
Marble
Rice
Field
J. L.
Thompson's
1203 ft.
35°
5.7
Marble
S
Granite
to N. cor. of Collins Tract
To Holmesville

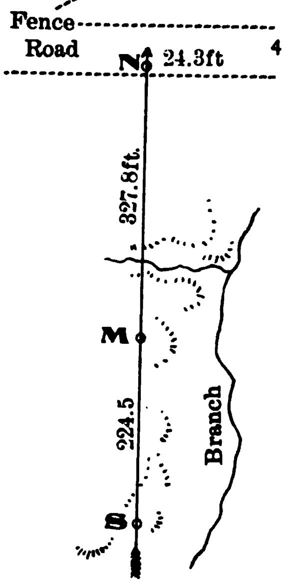
8

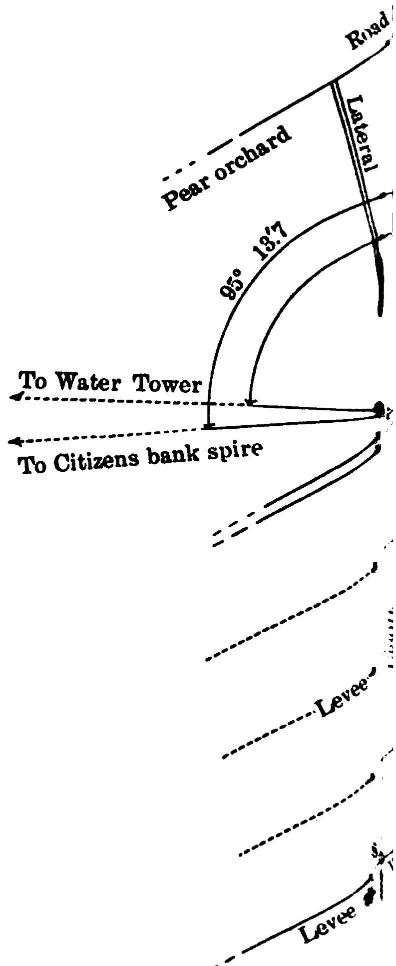

N'
N
Fence
Dr. Isaac
Bonsel
779.8 ft.
Garden
Residence
S'
Hedge
Office
Road

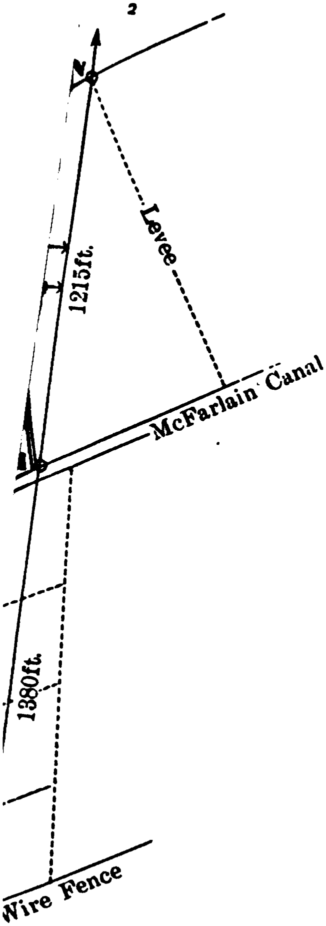
EXPLANATION OF PLATE XVI

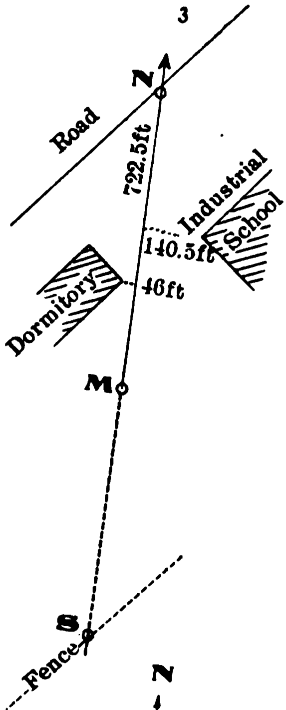
EXPLANATION OF PLATE XVI

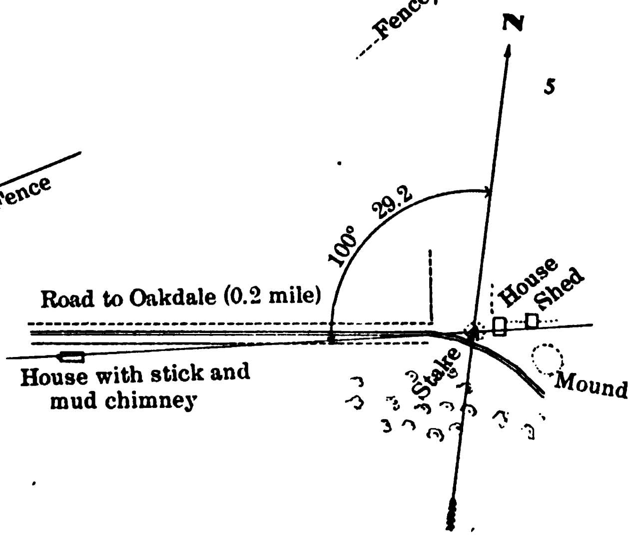

Street
Fence
N
School
Building
M
S


Fence
Road
N
24.3ft
4
327.8ft.
M
224.5
Branch
S


Road
Lateral
Pear orchard
95°
13.7
To Water Tower
To Citizens bank spire
Levee
Levee


2
N
Levee
1215ft.
McFarlain Canal
1380ft.
Wire Fence


3
N
Road
722.5ft
Industrial
School
140.5ft
46ft
Dormitory
M
S
Fence


N
5
100°
29.2
Road to Oakdale (0.2 mile)
House
Shed
Stake
Mound
House with stick and mud chimney

STATE EXPERIMENT STATION

BULLETIN

OF THE

LOUISIANA

GEOLOGICAL SURVEY

No. 3.

ESTABLISHMENT OF TIDE GAGE WORK.

BATON ROUGE

1905

BULL. No. 3. REPORT OF 1905

GEOLOGICAL SURVEY OF LOUISIANA

GILBERT D. HARRIS, *Geologist-in-Charge*

A REPORT

ON THE

ESTABLISHMENT OF TIDE GAGE WORK

IN

LOUISIANA

BY

G. D. HARRIS

MADE UNDER THE DIRECTION OF THE STATE EXPERIMENT STATIONS,

W. R. DODSON, *Director*

BATON ROUGE, LA.

1905

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The Bulletins and Reports will be sent free of charge to all farmers by applying to Commissioner of Agriculture, Baton Rouge, La., or to the Director of the Stations, Baton Rouge, La.

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BY

W. R. DODSON

STATE EXPERIMENT STATION,
BATON ROUGE, La., July 1, 1905.

TO HIS EXCELLENCY, NEWTON C. BLANCHARD, GOVERNOR OF LOUISIANA:

Sir:—I have the honor to transmit herewith *Bulletin No. 3* of the State Geological Survey. This like No. 2, marks the beginning of permanent record-making in an important branch of geological work in the State of Louisiana.

Respectfully submitted,

W. R. DODSON.

LETTER OF TRANSMITTAL

BY

G. D. HARRIS

CORNELL UNIVERSITY,
ITHACA, N. Y., June 10, 1905.

DR. W. R. DODSON, DIRECTOR OF THE EXPERIMENT STATIONS OF LOUISIANA:

Sir:—I herewith transmit to you *Bulletin No. 3* of the Louisiana State Geological Survey.

As your predecessor well knows, we have long had in mind the establishment of Precise Level work in the southern part of Louisiana. The reasons for undertaking such work are discussed at length in the pages which follow; but may be summarized as follows: (1) To furnish bench-marks for local surveys especially for canal and railroad work, and (2) to determine, in the course of time, the direction and rate of vertical movement in the earth's surface in this region, a point of interest to land owners and geologists alike.

Work of this nature requires some definite and well determined plane of reference. This plane is best determined by a long series of tidal observations. We have established a Tide Gage Station on Weeks Island, and the Coast and Geodetic Survey is helping us to maintain the same. Since March 25 a continuous record of the tides has been obtained at the Station.

Most respectfully yours,
G. D. HARRIS,
Geologist-in-charge.

THE ESTABLISHMENT OF TIDAL GAGE WORK IN LOUISIANA

BY

GILBERT D. HARRIS

INTRODUCTION

When the British Association for the Advancement of Science met at Dover, 1899, Sir Archibald Geikie,* Director of the Geological Survey of Great Britain, read a paper in which he called special attention to the fact that what we now most need in geological investigation is precise measurements. What is the rate of geologic work? We know full well the general sequence of geological events, but we are woefully ignorant of the time, say in years, that even the more recent geological epochs represent. What we need is more data relating to present crustal movements; and the way to obtain such data, perhaps not for ourselves but for our posterity, is to make a beginning by establishing indestructible bench-marks and running precise level lines connecting them, or determining their present relative elevations; but elevations imply a basis or zero point from which to reckon, and by general consent mean sea-level is used for this zero or plane of reckoning, the world over. But to determine our zero plane is a matter of considerable time, thought, and expense; this Bulletin contains an exposition of the method we have employed to accomplish this desirable end.

In the establishment of tide-gage work and precise leveling in south western Louisiana, we are following out the same general plan we have had in mind in previous survey work. That is, for example in Bulletin No. 2, we have shown how matters magnetic now stand in Louisiana, we have established a basis for

* See Geological Magazine, Decade iv, vol. vi, pp. 452–470, also Compte Rendu, viii Congrès Géologique International, 1900 Ier Fascicule, pp. 265, 274 : "De la Coopération Internationale dans les Investigations Géologique."

future work in terrestrial magnetism, a matter not only of the utmost present practical value, but of much practical and scientific interest for the future. The determination of mean sea level has also its practical and scientific bearings, present and future as well, as will be seen in the following pages.

PURPOSES OF TIDE-GAGE WORK, IN GENERAL

ECONOMIC

INTEREST OF TRANSPORTATION

The navigator of the high-seas provides himself before leaving his home port, with not only a Nautical Almanac, with log and sextant, wherewith to determine his position at sea, but with maps of ports to be visited, showing positions of buoys, lighthouses, etc., and with tide tables and lead and line wherewith to determine accurately the minor details upon entering harbor.

All this implies previous labor on the part of others. Somebody made the Nautical Almanac, somebody made the maps, the buoys and the tide-tables. Leaving aside all topics but the last mentioned as irrelevant to the subject in hand, let us consider for a moment what the construction of tide-tables means. Such tables, in order to be of value to navigators should be not mere records of past tidal observations, but should be predictions that will apply to the real date of the navigator's entrance to harbor. This means that the author of the tide-tables not only has a working theory of the tides, but has had access to a long series of readings made on the tides of that or some close-by harbor. Usually the continuous record of a self-recording gage for a period of one year will furnish the necessary data from which tidal predictions can be made for the next decade or two. A knowledge of such predictions is naturally imperative on the part of masters whose ships draw a depth of water practically equal to the depth of the channel at mean tide.

INTEREST OF LAND TITLES

Many of our laws distinguishing between national and State rights, between the State and individual, and the transactions between individuals imply a knowledge of "mean tide," "mean low tide," "high tide" or "tide water," and hence the more accurate and reliable knowledge there is to be had on the subject of the behavior of the tides in a given district, the less liability there is of misunderstandings and costly and useless litigation regarding property rights in neighborhoods within range of tidal waters.

IN THE INTEREST OF DRAINAGE

In preparing the dikes or levees to prevent the encroachment of the sea upon areas kept dry by artificial drainage two thoughts seem at once to be of paramount importance, viz.: how high does the crest of the highest wave ever rise above the usual sea-level of the district under consideration; and, is this district now rising or settling, and if so how rapidly. Naturally nothing short of a long series of carefully kept tidal observations will conclusively answer these inquiries.

PURPOSES OF TIDE-GAGE WORK; SPECIAL

GEOLOGIC AND GEODETIC

It is evident from our introductory remarks that no one is more appreciative of exact measurements relative to the present movement of the Earth's crust than the geologist. At the present time we can see where erosion is going on and where sedimentation is taking place; approximately too we can measure the extent of the work accomplished. Crustal movements of the earth are most assuredly brought about or at least greatly modified by changes of load caused by erosion, transportation and deposition. In past geological times we are not sure of the limits of land and sea areas, and the uplifts and downthrows that took place cannot be well correlated with definite geographical and physical data. From the natural phenomena we see about us to-day, as Lyell long ago pointed out, we are to learn

the real principles of geologic science. The ardor of our work is perhaps somewhat lessened when we realize the brevity of human life and the often exceedingly slow pace of the movements we are endeavoring to follow.

The very word tide-gage indicates that there is another object in recording the height of sea-level beside the mere determination of a datum plane from which to detect crustal movements of the earth. In fact the study of the tides themselves is at present engrossing the minds of some of our very best mathematicians. In order to predict tides the causes producing and modifying them in any particular locality must be fully understood. In other words, a tide-gage must be kept running in nearby waters for a sufficient length of time to admit of the determination of the constants entering the tidal formulæ. But the construction of these very formulæ depends on tide observations at a vast number of localities for long periods of time. Naturally then, all carefully kept observations are not only helping to explain the tides of that particular locality, but are helping to furnish the mass of evidence from which tidal laws can be formulated.

SPECIAL REASON FOR TIDE-GAGE WORK IN LOUISIANA

TO DETERMINE THE RATE OF RISE OR FALL OF THE LAND SURFACE

IN THE INTEREST OF DRAINAGE

Perhaps there is no region in the world where the soil is deeper and more fertile than in southern Louisiana. The driving of piles, the sinking of wells and the digging of numerous canals and ditches show that there is anywhere from four to twenty, forty or a hundred or more feet of rich "muck" that could if brought to the surface and kept from salt-water floods furnish a fertile soil that would be practically inexhaustible. But where the surface of the ground is so near sea-level, where lakes and gulfs or bays shade off indefinitely into impassible swamp-land and in turn the swamps give way insensibly to dryer

CALCASIEU LIGHT: SOUTHWESTERN LOUISIANA; SHOWING METHOD OF PROTECTING BUILDINGS AGAINST "TIDAL WAVE" ACTION.

areas already under cultivation, one is inclined to wish to know just what is the present rate of movement of the land surface and in which way is it going. In the swamp lands we see that where the sluggish bayous meander their way to the Gulf they have often laid bare a stratum of cypress and other kinds of stumps and logs some three or four feet beneath the present surface of the marsh. Drillings show that after passing through perhaps thirty feet of black carbonaceous mud, another stratum of logs and stumps may be encountered. In fact the deep oil wells show that these same marshy conditions may recur to a depth of 1800 or more. Sometime then, even in Pleistocene times that stratum which is 1800 feet down now was at the surface. A depression of that amount in comparatively recent geologic times, and the occurrence of sound roots, stumps and logs beneath broad stretches of marshland where now only tall marsh reeds and grasses grow are highly suggestive of the comparative swiftness of crustal movements in southern Louisiana.

TO DETERMINE THE EXTREME RANGE OF "TIDAL WAVES."

IN THE INTEREST OF DRAINAGE AND SAVING OF HUMAN LIFE

All people of south Louisiana are familiar with the so-called tidal waves that occasionally sweep the coasts of this and adjoining states.

As an example of extreme precaution to prevent the destruction of the lives of any of the employees of the United States we note the position of the light-house near Calcasieu pass. See Pl. XVII. Questions regarding the height of the crest of such waves are frequently asked of the Tidal Division of the Coast and Geodetic Survey, but owing to the few tidal observations along this coast, especially of this extraordinary nature, little information can be furnished. The mere statement of observers of such phenomena cannot be trusted since most varied and widely diverging opinions are given by persons observing apparently the same phenomenon. One of the last great waves not only destroyed the gage station at Isle Derniere but drowned

the observer. Hence the need of observers so located that although the small and inexpensive station house be destroyed, they shall be so located as to be in easy access to the waters edge and have abundant opportunites to retreat to higher land as the flood advances. The trained observer will simply note the height of the flood at certain definite periods of time say every ten minutes on building piles, trees or other fairly permanent objects and when the flood subsides, by a simple series of level lines connect all points with his former shore or upland bench-mark. Such trustworthy data will be of great value to not only the prospective cultivator of these low-lying fields, but will furnish the data from which to work out the rate of progress, and general character of such "tidal waves."

TO FURNISH UNIFORM STANDARD BENCH-MARKS FOR SURVEYORS AND ENGINEERS IN SOUTHERN LOUISIANA

IN THE INTEREST OF CANAL WORK

Passing inland from the vast areas of southern Louisiana that must be artificially drained in order to be of value from an agricultural standpoint we meet a still broader stretch that from its peculiar soil characters and floor-like smoothness is destined to be one of the great rice-growing areas of the world. For, these features with favorable climatic conditions combine to make rice culture a success. But rice fields must be flooded during certain seasons of the year. This implies artificial levees, ditches, pumping plants, etc., all so well figured and described in government, state and local publications, they may be passed by without further notice here. But the construction of canals and levees implies previous surveys whereby the proper location of the same has been secured. Heretofore a vast number of short lines of levels have been run by local surveyors each one starting from an arbitrary bench-mark of his own repeating the work if desirous of being sure he has made no mistakes.

Our intention is, by a long series of tide-gage readings to determine the elevation of a few sea-coast bench-marks with great accuracy, and from them run a line of precise levels along the

Southern Pacific R.R. and establish at intervals of say every five miles permanent bench-marks and thereon give the true height of the same above sea-level. All local lines can then be referred to one datum plane and when local surveys extend for a few miles in an east-west direction, both ends can be tied to reliable bench-marks and the accuracy of the local survey can be tested without the expense of duplicating all the work. Fairly reliable local bench-marks many miles distant from the above-mentioned railroad will very soon be left by local engineers and the mapping of the region topographically will be greatly facilitated. The time saved in running and re-running level lines will in a few years amount to tens of thousands of dollars.

WEEKS ISLAND AN IDEAL LOCATION FOR A TIDE-GAGE STATION

ACCESSIBILITY

BY RAILROAD

By referring to Pl. XXIII and XXIV it will be observed that a modern tide-gage includes several mechanical devices among which are two clocks, one to record time and one to drive the roll of paper on which the tide record is made. The clocks are of the eight-day type, but they and all the accessory machinery need looking after at least every other day. If anything breaks it must be repaired at such a shop as the nature of the repairs suggest. In other words some intelligent person must be looking after the gage constantly and he must have ready access to the more modern means of communication with the world. Weeks Island is the only point in this part of Louisiana where the railroad practically touches the broad Gulf waters.

BY TELEPHONE AND BY EXPRESS

By long distance telephone New Orleans can be reached; by telegraph, St. Louis, Chicago, Washington or New York, and by cable, the whole world. The Wells Fargo Express Company has an office within less than a mile of the Station.

LOCALLY THE STATION IS ACCESSIBLE

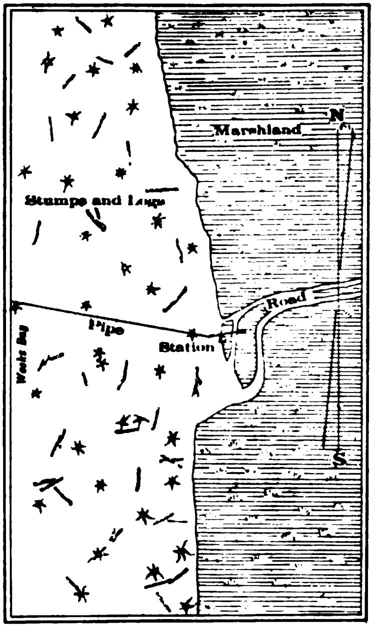


FIG. 13.—*Map showing the surroundings of the Weeks Tide Station.*

From the terminus of the railroad there is a good road to the station, about three-fourths of a mile distant. See fig. 13. As might be expected, this road has to pass over some swamp-land, but the gage is within less than half a mile of what may be called solid earth. In fact the upland clays are so firm and compact as to render digging with a spade very difficult. The resemblance of the same to glacier-compressed clays in the north is remarkable.

ABSENCE OF GREAT SEA SWELLS AND STORM WAVES

Pl. XVIII shows how the fury of sea storms is cut off by Marsh Island and the peninsulas about Côte Blanche Bay, and how the force of the great waves is checked by the extreme shallowness of Vermillion Bay, and finally how two points cut off Weeks from the rest of Vermillion Bay.

TRUE SEA LEVEL IS INDICATED

There must always be a serious doubt about the records of tide-gages located at or up some distance from the mouth of tidal streams, however large they may be. For even these sluggish bayous of southern Louisiana are generally flowing in fairly well defined channels. During the ordinary high tide, the marshlands seem at least one or two feet above tide. When it rains, several inches during twenty-four hours as it is wont to do in this region, these tidal channels receive a large amount of water and indicate a level considerably too high. The result of such

age readings, however necessary in tidal work, cannot be egarded as satisfactory from a sea-level standpoint; a point of he utmost importance to the geologist.

Pl. XVIII shows this gage to be located immediately upon he broad waters of Weeks and Vermillion Bays.

DESCRIPTION OF THE WEEKS TIDE-GAGE STATION

GENERAL LOCATION

LOCATION OF BENCH-MARKS

By consulting the outline map of Weeks Island herewith given (see fig. 14) a general idea of the location of the gage on the

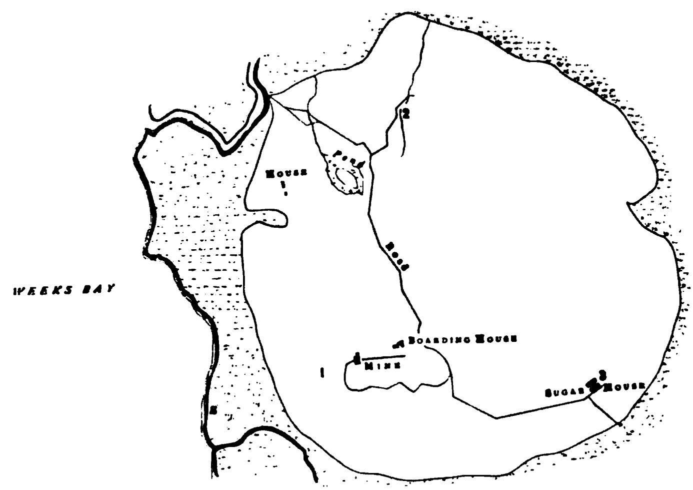


FIG. 14.—*Outline map of Weeks Island, showing location of bench-marks*

Island will be obtained. First note the mine, the terminus of the railroad. Then to the west perhaps 250 yards will be seen Bench-mark No. 1. Farther westward, at the water's edge is the Tide station building. In the northern part of the Island, about twenty yards from a private road, and perhaps five yards from a stream bed is Bench-mark No. 2. These two bench-marks appear

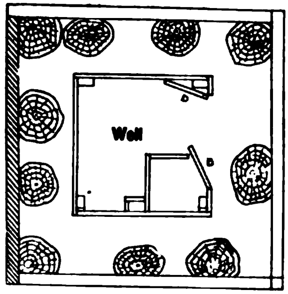
above the surface as shown in fig. 15, but the permanent mark is the head of a brass bolt set in cement at a depth of about 4 feet beneath the surface of the ground. Bench-mark No. 3 is a hole in the wall of the old Sugar House in the south-eastern part of the Island. See fig. 16. The purpose in locating these bench-marks in distant parts of the Island is two-fold; first to guard against any possible destruction of all by one and the same cause; second, to be able in the future to detect any differential uplift or downthrow in the Island itself. Before the work is complete it of course will be necessary to connect all these points with some mark off the Island, say at Cypremort, Glencoe or Baldwin.

FIG. 15.—*A photograph of bench-mark No. 1.*

FIG. 16.—*A photograph showing the location of bench-mark No. 3.*

By the Station a bench-mark has been established a few feet from the shore so that in case the staff is destroyed it can quickly be re-established at its proper level.

HORIZONTAL PROJECTION



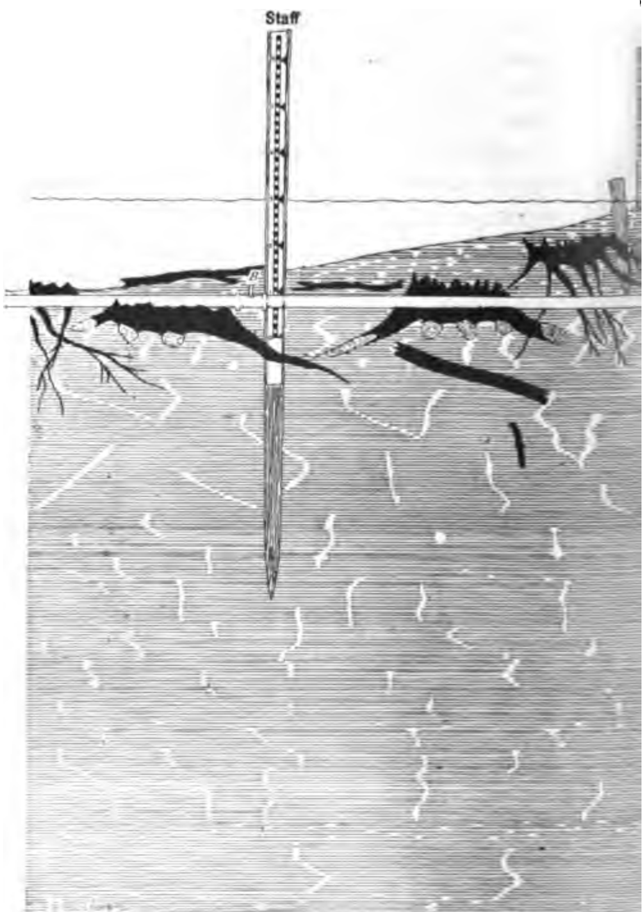
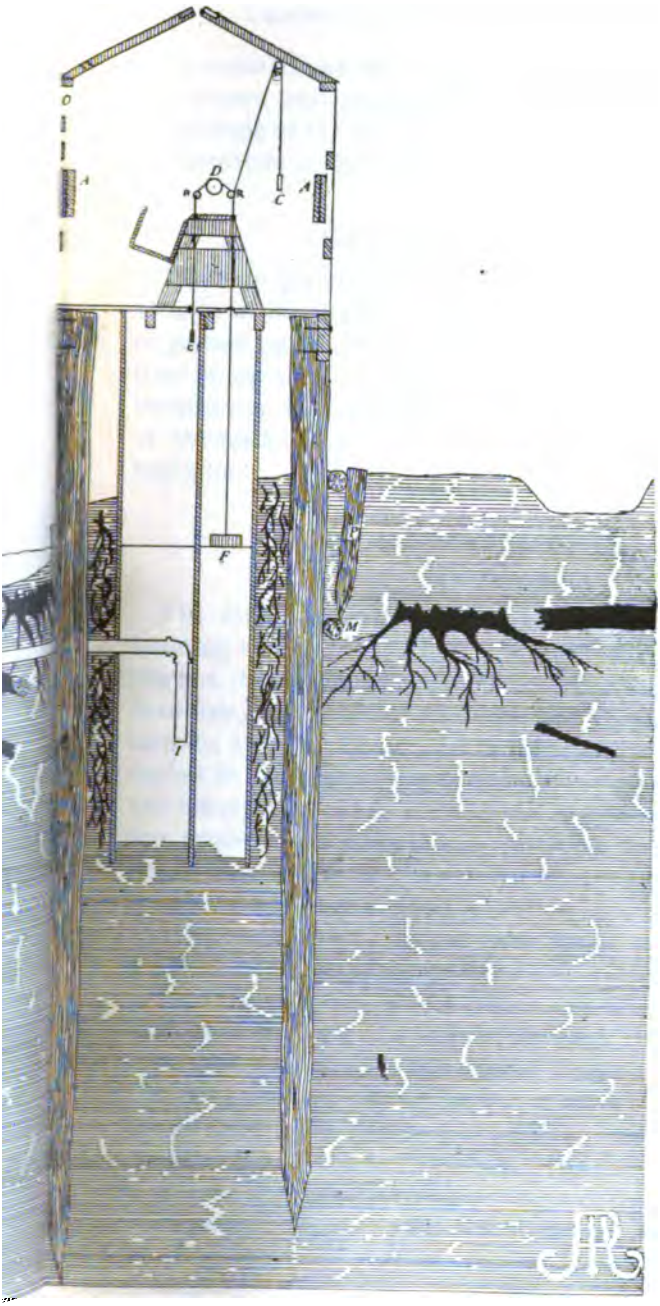


Diagram of the Ti

1



...DE GAGE STATION

By calculations based on the Coast and Geodetic Survey map and known local geographic features we can say that the

Latitude of the Station is 29° 48′ 0″ N. and the

Longitude of the Station is 91° 49.5′ 0″ W. from Greenwich.

IMMEDIATE SURROUNDINGS

The map given as fig. 13 shows the details of the immediate vicinity of the Station. By ditching we have converted the plat of ground on which the station stands into an island except in time of low tide. A foot-bridge has been constructed from the terminus of the road to the door of the house so that even in case of unusually high tide the observer is not troubled by water and mud.

THE BUILDING

FOUNDATION

The illustrations (Pl. XIX) show the main features of the building and its foundation. We will simply call attention to the fact that in marshy regions no better foundation can be had than one constructed of a number of Cypress piles driven firmly into the ground. Those used in this foundation were from 8 to 12 inches in diameter at one end and tapering to about 6 inches at the lower end. They were driven in by a very simple and primitive process; but since others may wish to construct a similar foundation, where no pile-driving machinery is at hand, we will briefly describe our method.

A common winch, geared back about ten times, with iron drum about 5 inches in diameter was firmly pegged to the ground. A 1¼-inch rope was passed about the drum and its free end secured to the apex of a tripod (with legs about 25 feet long) and the tripod was raised to the desired height.

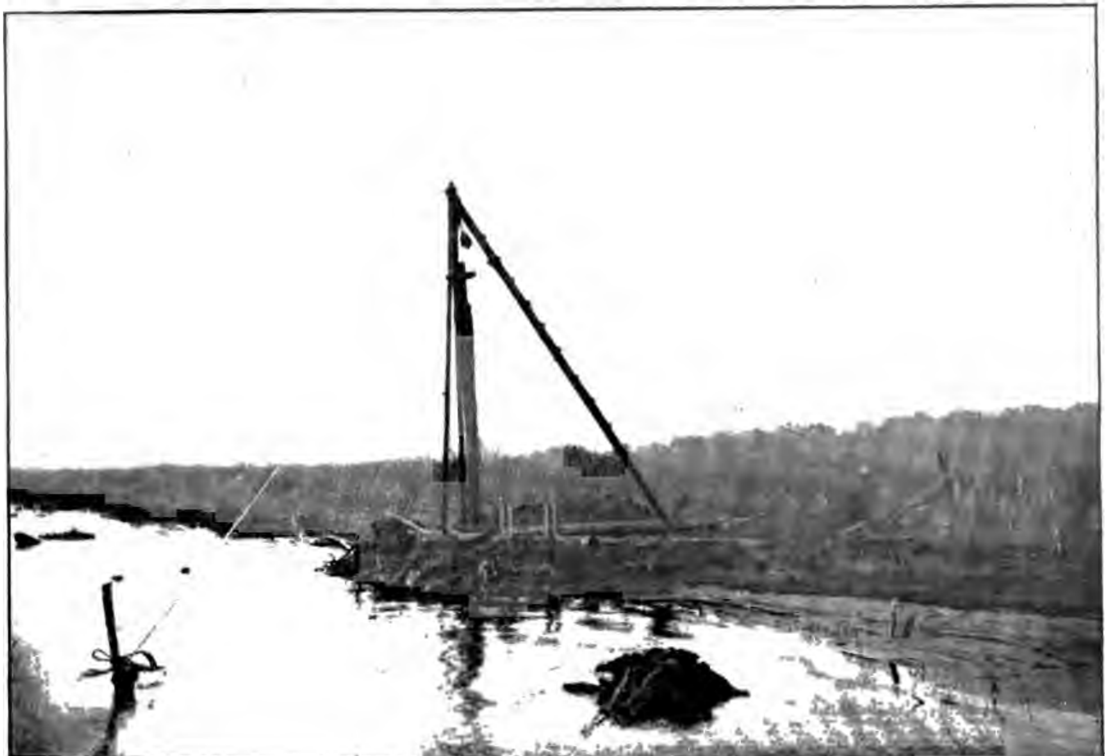
A pulley at the apex of the tripod served to deflect the direction of the rope so that by hitching the free end of the rope to the piles they could be lifted bodily to a sufficient height to admit of placing their sharpened end wherever they could be most advantageously driven. Pl. XX shows the first pile in position for driving. The driving process consisted of letting down a

Cypress log one foot square and three feet long quickly upon the upper end of the pile. This wooden hammer and the pile were in the meantime held in place by means of two vertical board runners secured by guy ropes. The necessary pounding motion was brought about by wrapping the aforementioned rope about the winch drum but once, and while one man turned the crank, the other held this one coil tight and hauled away the slack rope so that the proper amount of friction was secured to hoist the hammer. When the latter was at the desired point of elevation, the man at the rope suddenly loosened the coil about the iron drum and the hammer descended upon the head of the pile. As the pile descended the hammer naturally dropped farther and farther and hence, although the friction of the pile through the earth naturally increased, the descent at each blow of the hammer averaged about three-fourths of an inch. The driving of two piles represents a good day's work for two men. It will be noticed by Pl. XIX (Horizontal Projection) that the piles are not symmetrically arranged beneath the house. The reason is that there were still a number of pieces of firm stumps and roots by the side of and beneath those thrown out by dynamite that could not be driven through. The larger number were put seaward for it was thought that they would be needed for a breakwater in case of heavy storms. The number of these large piles as shown by the figure just referred to is ten. They are secured to each other beneath the surface of the ground by mud sills (M), and above ground by diagonal two by eight inch cypress planks, and at top by three by twelve inch cypress planking, all secured by half or five-eighths inch lag bolts from eight to twelve inches long.

THE WELL

Pl. XIX shows that within the quadrangle of cypress posts just described there is a well with wooden curbing.

This as shown is about feet deep. It passes beneath the stump and log layer and has but one opening beneath water level, on the seaward side for the entrance of the pipe. No really firm earth was passed through in sinking this well, but the stump and log layer forms a very compact mass; so completely do the roots and logs make up this stratum that it is difficult to find a place



METHOD OF PILE-DRIVING FOR THE WEEKS TIDE STATION

THE HOUSE AND STAFF

where even a small rod can be pressed deeply into the ground. However, if such a place is found, a rod 12 feet or more in length can be pushed down by hand, *i. e.*, without resorting to driving.

The several large stumps occupying the area through which the well passed were lifted out together by a heavy charge of dynamite.

THE HOUSE

The plates and figures given herewith show the general character of the building itself. It is approximately a six-foot cube, with one door, and one small window opening seaward. It is constructed mainly of corrugated iron on account of the prevalence in this region of marsh fires. The little ditch about the house before referred to was dug for the same general reason. The frame-work of the building is of two by four-inch cypress, though at each corner there are four by four posts. Running from the corner piles, across the three by twelve planking already described and far up the corner posts are bands of iron one-fourth by two inches, bolted in the wood from top to bottom. These are intended to hold the house to the foundation in spite of anything but the severest gales or hurricanes that may visit this region. Again, the iron sheeting is firmly nailed to the three by twelve-inch cypress planks about the base of the entire building; and the framework is otherwise secured to the piling.

The tide-gage is mounted upon a heavy frame of woodwork; and around the inside of the building at about the height of the most delicate parts of the instrument a three-inch cypress plank (*A*) is bolted. The object of the latter is to prevent the bullets of wanton huntsmen from reaching the instrument, for a lone house on the shore is a tempting target for a huntsman's leisure moment. Ventilation is secured by leaving a crack at the ridge, for the exit of warm air, while the same is covered over by a metallic raised ridge-piece. Light enters through a small window (*O*) opening toward the west, protected on the outside by an iron grating.

THE PIPE

If one is accustomed to ordinary shore materials, sand, clay or rocks, he can scarcely realize the quickness with which the material in this locality will close any open passage from the sea to a tide-gage well. The water will stand at quite a different level in well and just outside. The marsh earth is little else than peat and since its specific gravity is so low it is carried about by the waves and washed into all depressions, except of course when held in place by roots of marsh reeds and grasses. To secure communication with the clear Gulf waters in this case a pipe, two and one-half inches in diameter (inside) was run out 150 feet to sea and landed on a log 6 inches in diameter, thus holding the pipe well above the bottom of the Bay. To prevent the entrance of marine or aquatic animals of any considerable dimensions in the pipe, its outer end was closed by a large Cypress plug, while the outer foot of the pipe was honeycombed by half-inch holes.

It was our intention to have this pipe, for its whole length well below the lowest water known; since in January ('05) a few very low tides showed that the sea occasionally retreated and left quite a stretch of the shore bare. See Pl. XXII. The idea could not be carried out this year, for very soon it was seen that the low tides in January were of the most exceptional character and that digging beneath several feet of water, although easy enough in general was rendered almost impossible by the presence of the aforementioned stump and log layer. Worst of all the gage furnished (scale 1 to 6)* will not take in all the lowest waters and at the same time take in the crest of high or unusual flood tides. The gage is therefore set and provision made for recording accurately during the greatest number of days of the year. By a siphon arrangement, accompanied by an air-valve (*B*) at (see Pl. XIX) it is believed that except in very unusually low tides (when the recording pencil is off the paper) the well will be filled to its proper level. There will be periods, though very short too when the pencil will be off the other end of the recording drum.

*P. S.—Since the above was the scale has been changed to (1 to 9).

A LOW WINTER TIDE AT THE SITE OF THE WEEKS STATION

THE STAFF

Out a few feet from the northwest corner of the building is a staff gage on which feet and tenths are clearly indicated. The use of the same will be described later on, but here it may be said that the staff consists of a cypress post about six inches in diameter driven into the bottom of the Bay about eight feet and projecting above the same datum plane about five and one-half feet. On this is nailed the board graduated as just described. The board scale is six and one-half feet long, and the feet are numbered from the bottom up. Naturally mean tide should read a little over three feet as it does. In case this scale is destroyed it can be recovered by reference to a shore bench-mark.

SHORE BENCH-MARK

As fig. 13 indicates there is a bench-mark a little to the north and across the ditch from the house. This consists of a piece of an old elliptical pipe, averaging perhaps two inches in diameter, four feet long, driven vertically into the ground, to such an extent that the upper end of the pipe exactly corresponds to the 4½-foot point on the staff, while the top of a cypress plug driven in the upper end of the pipe is on a level with the 5-foot mark on the staff. Again in a little bay or what might be called road-ditch east of the house, a wooden plug 6 inches in diameter and 3 feet long is driven in such a way that the upper end of a bolt inserted in the upper end of the plug is on a level with the 3-foot mark on the staff. This bench-mark serves as an excellent auxiliary staff for when the waves are high and the water is rough about the main staff, a graduated board can be let down upon this bolt and the exact reading made in quiet waters. The tying up of these bench-marks with those of the Island proper will be discussed later.

THE SELF-RECORDING TIDE-GAGE

Although modified in a few respects from the gage shown by plates XXIII and XXIV, the essential features of the Weeks station gage are the same. A roll of paper sixty-odd feet in length is placed upon a brass axle, the paper is unwound, passed

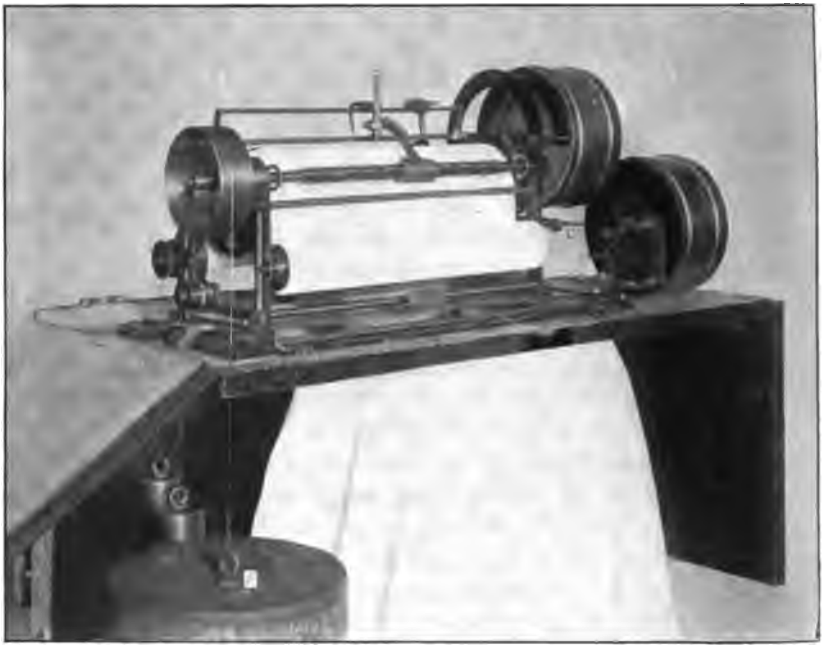
over a drum or large brass roller and is wound around a third roller. The large drum is made to revolve by means of a substantial clock, the upper as shown in Pl. XXIII. Small pins in this drum puncture the paper and cause sufficient friction to unroll the paper from the roll upon which it is wound. The third roller is caused to revolve, thus taking up the slack paper, by means of a counter-weight. As the paper passes over the large brass drum, at the rate of about 1 inch per hour it has traced upon it a curved line representing at a certain fixed scale the height of the tide continuously by day and night. The tracting of this curve is brought about in this style of gage by the lifting and settling of a float (*F*) in the well below; for to it is attached a wire that passes over one end of a shaft that turns, and returns, by means of a counter-weight, as the tide ebbs and flows. On this shaft a very coarse spiral thread is cut, and on the same a nut works, moving the pencil R as it goes.

A second, ordinary time-keeping clock accompanies this instrument and by an automatic arrangement (see T and P) it causes at the end of each hour a slight back and forward movement in the recording pencil Pl. 23. It is evident that if the gage is visited daily or semi-daily, and time of day, and date of the month are noted on the roll opposite the position of the recording pencil at that time, the time when the pencil was at any particular place on the recorder curve can quickly be reckoned.

By Pl. XIX it will be seen that we have placed the counterweight of the float in the house itself and in such a way that the pull lifts up on the axis of the cylinder over which it winds. The reason for this is that when both float and counter-weight pull down on the axis of the cylinder there seems to be much more friction than when the counter-weight passes over a brass pulley with much less bearing area.

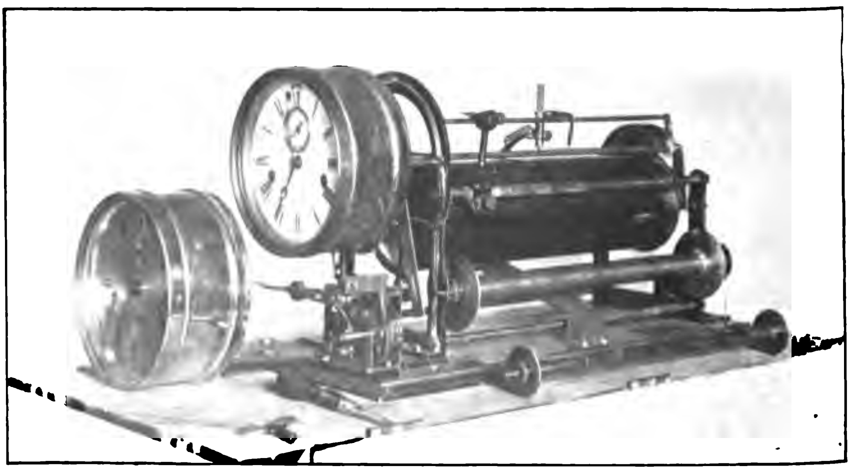
CARE OF THE GAGE

To keep a rather delicate piece of machinery in good working order calls for the attention of some reliable, intelligent, person of at least a fair degree of mechanical ability. But no one could think of spending his whole time in the care of a single



A SELF-REG STERING TIDE-GAGE; BACK VIEW

PLATE XXIV.



A SELF-REGISTERING TIDE-GAGE; FRONT VIEW

instrument of this kind. One hour a day ought to amply suffice for going, coming and work at the station. If therefore some one with other employment can be at liberty an hour a day or even every other day the machine will be kept properly at work.

No better person could be had for the work than the present observer, Mr. R. H. Hinton of the Myles Salt Company. The understanding with the Coast and Geodetic Survey (the organization furnishing the instruments used) is that the observer's salary of $15.00 per month be paid by that Survey, for the period of three of five years, or the length of time necessary to properly determine the nature of the tides and the mean sea-level at that station. The cost of constructing the house and putting the gage in operation was borne by the State Geological Survey.

The observer must see not only that the clocks and counter-weights are properly wound up and that the clock is keeping accurate time, but must see that the water is properly entering the well so that the height therein is the true sea level without. His method of determining this point is to note the staff reading without and compare it with the place of the recording pencil on the paper at the same instant. He must while visiting the gage read the staff and record on the record opposite where the pencil is at that moment just what the staff reading is, noting also date and exact time of making the observation. This serves as a check to the correctness of the automatic record of the clock. The most valuable staff readings are made near high and low tide when the pencil is moving almost parallel with the edges of the recording paper. For, any little error of time at which the recording pencil was when the staff readings were made in such circumstances causes no appreciable error in the final record.

A READING SCALE

It often and in fact generally happens that waves of at least a few inches in height are lapping up and down on the staff and true sea level can only be guessed at. To get around this difficulty, a scale one foot in length and divided into tenths and hundredths was made, and on the same was fastened a glass tube of equal length. By plugging up the bottom of this tube leaving

only a very small hole open, and holding it alongside the staff, matching some even foot on the same, the mean position of the water can readily be ascertained.

A SUN DIAL

Whenever a tide gage is situated close to a railway station where daily noon signals are received from Washington it is comparatively easy to keep a watch or clock running within a minute of Standard Time. At Weeks, signals can be sent from Franklin but this requires unnecessary labor and expense. For, we erected a small sun dial on the south end of the Salt Company's Office that records apparent noon to within one-half minute; and knowing the longitude of the place, and having at hand a Nautical Almanac a table was quickly constructed for the reduction of Apparent to Mean 90° Meridian time.

BENCH MARKS

NUMBER 1

The general plan of the marker is indicated by fig. 17. The plan of construction was as follows: First a hole was sunk in the ground to a depth of nearly five feet. In this hole freshly made cement was poured. When it had hardened somewhat, a hole was drilled in the center of the disc-shaped block and a brass bolt inserted. The latter was ½ inch in diameter, 3 inches in length and with a plano-convex head 1 inch across. Afterwards a 4-inch pipe was placed over the brass bolt and the hole was refilled. On the upper end of the pipe an iron cap was bolted and through its uppermost surface a rounded brass plug protrudes. Ordinarily the top of this plug will be used as the point of reference. But in case the pipe seems to have been disturbed the cap should be removed and the leveling rod let down to the lower bolt. The difference in

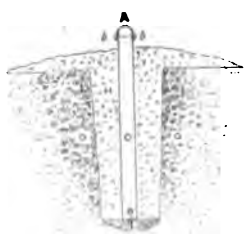


FIG. 17.—*Plan of bench-marks Nos. 1 and 2.*

elevation of the crests of these brass rounded surfaces is 5.2885 feet.

The tying up of this bench-mark with those at the gage station is attended with some difficulties. We had a very fine level loaned to us by the U. S. Coast and Geodetic Survey, but the rod was very poor, crooked and hard of manipulation. One great difficulty encountered was the springy nature of the ground along the marsh road. The changing of position when seeing that the bubble was properly situated to the position for sighting would cause the instrument to change level to a marked degree. This trouble was largely obviated by carrying along a long stiff plank on either end of which a cross-piece was nailed. The man at the instrument was then able to have his weight transmitted some distance away from the legs of the instrument by standing on this temporary bridge. Add to their troubles the extensive "boiling" of the atmosphere above the marshland and the vigorous attacks of swarms of mosquitoes and the true conditions of affairs may be realized.

Naturally with the equipment at hand under such circumstances our results were far from ideal. Three measurements from the top of the brass plug on top of the cap of No. 1 to the top of the wooden plug in the shore bench-mark or what is the same thing, to the 5-foot mark on the staff were as follows:

Feb. 25, P. M., 1905	18.353 feet.
Feb. 27, A. M., 1905	18.335 feet.
Feb. 28, P. M., 1905	18.333 feet.

The method used in all cases was to take three sightings at the rod at each setting of the instrument and call the mean of the three the true reading.

NUMBER 2

This is very similar to No. 1 and need not be specially described. However the distance between the crests of the two brass surfaces is slightly less, being but 5.274 feet.

Duplicate leveling with triplicate rod readings show that the top of No. 2 is 18.031 feet above the same part of No. 1 with a probable error of nearly .02 feet.

NUMBER 3

This is marked by a hole drilled in the brick wall of the Foote Sugar House; about four feet above the ground and perhaps an equal distance to the right of the central door shown in fig. 16. The hole was made with a half-inch drill, to a depth of about four inches. Elevation of center of hole above Bench-mark No. 1 was found to be 25.10 feet.

THE TIDES AT WEEKS STATION

PRESENT INDICATIONS

From our present limited observations we can of course speak only generally of the action of tides at this Station but we feel sure that there is an occasional difference of more than 6 feet in the tidal range. Yet as a rule, on calm days doubtless 1½ feet would be about an average range, though sometimes it is even less. Generally, however, the wind is blowing, and the bay seems very sensitive to air currents. As might be expected southerly winds, especially southeastern in course of a few hours bring in a high tide, if the expression is permissable. During the warmer months then, when there are no "Northers" we seem to have higher tides, the general level is higher than in winter. In January we have seen very low tides. Occasionally when the wind has been blowing steadily and hard for a day or so from the north the water seems to leave the shore for several hours and the beach has the appearance shown on Pl. XXII. This photograph was taken about January 20, after the northern wind had blown several hours. Ordinary southern storms do not cause the waves to break over the banks and show a depth on the marsh greater than half a foot. For the first three months of this year, we feel confident there have been no tides rising above the five-foot mark on the staff. The period of storms, however, comes later on in the season, especially in August or September. We believe mean sea level will prove to be between the three and three and one-half foot marks, probably about three and four-tenths.

STATE EXPERIMENT STATION

BULLETIN

OF THE

LOUISIANA

GEOLOGICAL SURVEY

No. 4.

UNDERGROUND WATER RESOURCES OF
NORTHERN LOUISIANA

BATON ROUGE

1906

Bull. No. 4 Report of 1905

GEOLOGICAL SURVEY OF LOUISIANA

GILBERT D. HARRIS, Geologist-in-Charge

GEOLOGY

AND

UNDERGROUND WATER RESOURCES

OF

NORTHERN LOUISIANA

WITH

NOTES ON ADJOINING DISTRICTS

BY

A. C. VEATCH

Made under the Direction of the
STATE EXPERIMENT STATIONS
W. R. DODSON, Director
1906

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AND A. & M. COLLEGE

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LETTER OF TRANSMITTAL

BY

W. R. DODSON

STATE EXPERIMENT STATION,
BATON ROUGE, La., Aug. 1, 1906.

TO HIS EXCELLENCY, NEWTON C. BLANCHARD, GOVERNOR OF LOUISIANA:

Sir:—I have the honor to transmit herewith *Bulletin No. 4* of the State Geological Survey. The investigation of the underground water resources of north Louisiana discussed in a preliminary way in Bull. 1 of this Report is herewith treated exhaustively by A. C. Veatch, a former employee of the State Survey.

The desirability of the investigation must be patent to all, and the way it has been prosecuted leaves little to be desired.

Respectfully submitted,

W. R. DODSON.

LETTER OF TRANSMITTAL

BY

G. D. HARRIS

CORNELL UNIVERSITY,
ITHACA, N. Y., July 15 ,1906.

DR. W. R. DODSON, DIRECTOR OF THE EXPERIMENT STATIONS OF LOUISIANA:

Sir:—I herewith transmit to you *Bulletin No. 4* of the Louisiana State Geological Survey.

The general plan and object of the investigation herewith reported upon has already been set forth in Bulletin No. 1. Though the publication has been considerably delayed, the present paper is far more complete and satisfactory than it could have been if published when Mr. Veatch first left the State Survey and proceeded to investigate the surrounding States under the auspices of the United States Geological Survey. The complete report on all these areas has been published by the National Survey as Professional Paper No. 46, entitled, "Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas." Excerpts from this elaborate paper dealing with Louisiana territory form the subject matter of this bulletin. It is believed that citizens of the state will find this bulletin amply exhaustive and much more convenient for reference than the quarto professional paper just referred to.

Respectfully submitted,
G. D. HARRIS.

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ILLUSTRATIONS

GEOLOGY AND UNDERGROUND WATER RESOURCES OF NORTHERN LOUISIANA WITH NOTES ON ADJOINING DISTRICTS

BY

A. C. VEATCH

CHAPTER I

GEOLOGY

INTRODUCTION

OUTLINE OF MAJOR FEATURES OF PRESENT TOPOGRAPHY

Topographically northern Louisiana and southern Arkansas form an area which is divisible into two major provinces, the Ouachita Mountains and the Gulf Coastal Plain.

The Ouachita Mountains province is a region of relatively great and rugged relief, ranging from 500 to 2,000 feet above sea level and composed of roughly parallel ridges separated by deep, flat-bottomed valleys. It is underlain by a much folded, steeply inclined, deeply eroded series of Paleozoic sandstones, shales, and limestones, and has been developed from the slightly arched surface of an old peneplain by the erosion of the softer beds.

The Gulf Coastal Plain is an area of low and rounded relief, extending in this region from 3[1] to 600 feet above sea level

[1] The elevation of extreme low water in the Mississippi at Red River Landing, November 14, 1895 (Ann. Rept. Chief of Engineers for 1900, pt. 4, 1900, pp. 2543-2544). According to the maps of the Mississippi River Commission the beds of Red, Ouachita, and Mississippi rivers and of Bayou Macon and Boeuf and Tensas rivers often extend to considerable depths below sea level; thus the Mississippi at Vicksburg (Klineston) reaches a depth of 58 feet below sea level, at Fort Adams 112 feet, and at Miles Landing, 4 miles below the mouth of Red River, 127 feet.

Geologic subdivisions.				CHARACTERISTIC Deposition. Thickness.	Character.	
Quaternary.	Recent.	Alluvium.		*Feet.* 0– 20+	Veneer of sand, silt, and clay on flood-plains.	
				0– 25	Abnormal deposits of silt in Red River Valley resulting from the obstruction by the "great raft."	
	Pleistocene.				Formation of natural mounds.	
		Port Hudson formation.		0– 200	Marine deposits on the coast and fluviatile deposits in the river valleys, partly filling the broad valleys developed in the preceding erosion cycle.	
					Rearrangement of surficial sands and gravels at new levels as erosion progressed.	
Tertiary.	Pliocene.	Lafayette formation.		[1]10– 50	A mantle of silt, sand, and gravel spread by combined marine and river action over the relatively even surface of the Coastal Plain and in the tributary valleys.	
	Miocene.					
	Oligocene.	Fleming clay.		±260	Green calcareous clays, with a few brackish-water fossils.	
		Catahoula formation.		1,000–1,200	Near-shore deposits; sandstones occasionally quartzitic, and green clays, with fresh-water shells and land plants.	
		Vicksburg formation.		100– 200	Limestones and calcareous, somewhat lignitiferous, clays, containing marine shells.	
	Eocene.[2]	Jackson formation.	Undifferentiated Eocene.[2]	200– 550	Highly fossiliferous shallow-water marine sandy calcareous clay.	
		Cockfield member of Claiborne.[3]		400– 500	Lignitiferous sands and clays, with land plants.	Landward these formations merge into lignitiferous sands and clays without distinctive marine fossils.
		Claiborne formation.		200– 500	Fossiliferous sandy clay, containing shallow-water marine shells.	
		Sabine formation.		300– 900	Lignitiferous sands and clays, with plants and occasional beds of marine shells.	
		Midway formation.		20– 260	Limestones and black calcareous clays.	

[1] Normal thickness in northern Louisiana not known because of the widespread and irregular deposition. In southern Louisiana the beds are much thicker than here given.

[2] The Jackson, Claiborne, and Sabine formations, which are fossiliferous and distinct in central Louisiana, grade into lignitiferous beds containing no distinct fossils as they go northward. In the

northern Louisiana.

ACTIVITIES.

Degradation.	Deformation.
General degradation of the hill lands. Along Red River in Louisiana the resurrection of buried channels and the drainage of lakes produced by the "great raft." On the Sabine the partial wearing out of shoals produced by the recent movement of the Rockland-Vicksburg flexure.	A slight upward movement at the west end of the Rockland-Vicksburg flexure is producing rapids on Sabine and Angelina rivers. A recent movement of 25 feet along the line of the Red River-Alabama Landing fault has resulted in the swamping of Ouachita River Valley to a point above the mouth of Bayou Moro in Arkansas.
Partial removal of valley fillings and production of present flood-plains and principal terraces.	
Long and complex period of erosion, with the land 100 feet higher than to-day, in which the formations of the Coastal Plain were profoundly dissected and the major features of the present topography produced.	After the main development of the Angelina-Caldwell flexure the beds were faulted along a line extending from a point near Denison, Tex., through Alabama Landing, Union Parish, La. The downthrow of this fault is to the north and the break approximately 600 feet.
A period of erosion, probably composed of several stages, in which the Coastal Plain in this region was essentially base-leveled.	The low fold which extends from the vicinity of Angelina County, Tex., to a point north of Vicksburg, Miss., and which is now a line of weakness, began to develop in late Oligocene or early Miocene time North of this line the older beds are now nearly horizontal; to the south they dip at a rate of from 35 to 150 feet per mile. The domes developed during late Cretaceous and early Eocene time show a slight movement in post-Claiborne time, but the amount is very small when compared with the initial movements.
Beds separated by a pronounced break in the fauna, which is, at present, the only indication of a very serious break in sedimentation.	The great north-and-south fault of the Coastal Plain of Texas (the Balcones fault) developed late in the Cretaceous. In Louisiana peculiar domes or four-sided folds were produced and reached their major development in the late Cretaceous or early Eocene. About the same time masses of igneous rocks of limited area were intruded into the Paleozoic rocks and Coastal Plain beds in southern Arkansas. In central Texas similar occurrences took place as early as the Austin epoch. The Louisiana and northeastern Texas domes are thought to be due to the upthrust of similar igneous intrusions.

region under discussion the fossiliferous Jackson limits this lignitiferous complex above. Still farther north, however, the Jackson also grows lignitiferous and merges with the rest. The Midway, likewise, in the upper embayment region shows a decidedly lignitiferous tendency and may in places merge with the lignitiferous time equivalents of the other Eocene beds.

3 A group without distinctive marine fossils, probably almost wholly of Claiborne age.

(Pl. XXVII). It is underlain by a series of relatively soft strata, dipping on the whole gently seaward, in which the present topography has been formed entirely by the profound dissection of an old plain level. The surface of this old plain has now been almost completely destroyed (Pl. XXV, C and D), and the region presents two principal topographic divisions— (1) the hill lands and (2) the flood-plain and terrace areas (Pl. XXV, B); the former representing the uplands formed of rolling hills, composed largely of the older beds of the Coastal Plain, and the latter the lowlands, flat or benchlike in character, composed of redeposited sediments of rather recent fluviatile origin.

In the flood-plain region three features of very recent origin are to be noted— (1) the greater depth of Ouachita River Valley in southern Arkansas as compared with the Mississippi Valley at the same latitude (Pl. XXV, C); (2) the shoals and rapids which are found in the midst of strips of mature topography on Angelina River near its mouth, along Sabine River from Pendleton to Burrs Ferry, particularly near Columbus (Pl. XXXV, on Red River near Alexandria, and on numerous small tributary and distributary channels in the Red River flood-plain between latitude 32° and 33°, and on Ouachita River at Catahoula Shoals (figs. 24, 25), and (3) the lakes which occur or which formerly occurred in the lower part of each of the streams tributary to Red River between Alexandria and the Arkansas-Louisiana State line (fig 18). These lakes are the most important recent topographic features of this region, having been formed since the fifteenth century, but now the cause of their formation having passed, they are returning to their normal status as tributary streams. Several no longer exist, though still represented on maps because of the lack of recent detailed surveys.

In the hill lands the general character of the topography is irregular and rolling, the hills rising 100 to 200 feet above the flat-bottomed stream channels which extend in every direction, but the unequal hardness of the underlying beds has given rise to several transverse ranges of hills, which are more or less persistent for many miles and follow the general strike of the formations producing them. Of these the Kisatchie Wold* (Pl. XXV, A), which is produced by the hard sandstone layers in the

Areas less than 100 feet above gulf level.

Areas more than 400 feet above gulf level.

SALIENT TOPOGRAPHIC FEATURES OF THE GULF COASTAL PLAIN IN NORTHERN LOUISIANA AND SOUTHERN ARKANSAS.

BY

A.C.VEATCH.

Scale

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1905

From U.S. Geol. Surv.

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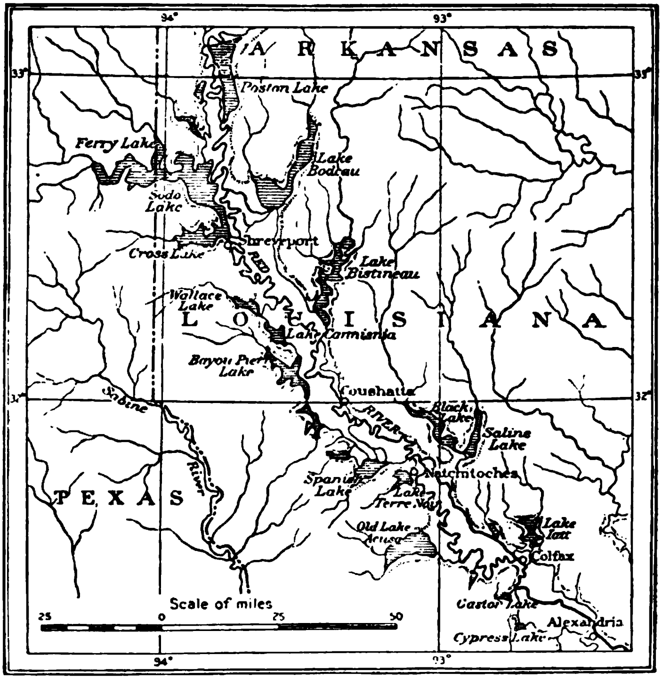
Catahoula (Grand Gulf) formation, is perhaps the most important. Others are the Sulphur Wold, formed by the sandy beds of the lower Eocene, and the Saratoga and Locksburg Wolds, by Cretaceous formations. The transverse valley or vale[2] to the



From U. S. Geol. Surv.
FIG. 18.—The lakes of Red River Valley in Louisiana at their fullest development.

north of the Sulphur Wold, though not very well marked, has determined the location of the Iron Mountain Railway between Little Rock and Texarkana.

Over all the Coastal Plain, except in the steeper hill areas and the most recent flood plains, are low, circular, mound-like elevations that are in themselves of minor significance, but are relatively important because of their persistence and wide distribution. They are from 20 to 100 feet in diameter and attain a

[2] For definition and derivation of the terms wold and vale see Prof. Paper U. S. Geol. Survey No. 44, 1906, p. 29.

maximum elevation of 6 feet. They are particularly abundant in the terrace areas, where in wet weather they form low, sandy islands in the midst of a water-covered clay country. Their origin is one of the most interesting and perplexing problems of the region.

HISTORICAL GEOLOGY

CRETACEOUS

INLYING AREAS OF THE UPPER CRETACEOUS IN NORTHERN LOUISIANA AND EASTERN TEXAS

Disturbances during the late Cretaceous or very early Eocene resulted in the formation of a number of steep domes or four-sided folds (quaquaversals) on the sea bottom in what is now northern Louisiana and eastern Texas (Pl. XXXVIII).

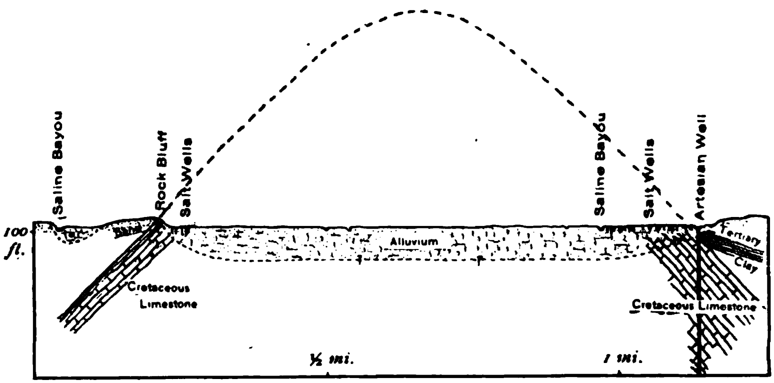
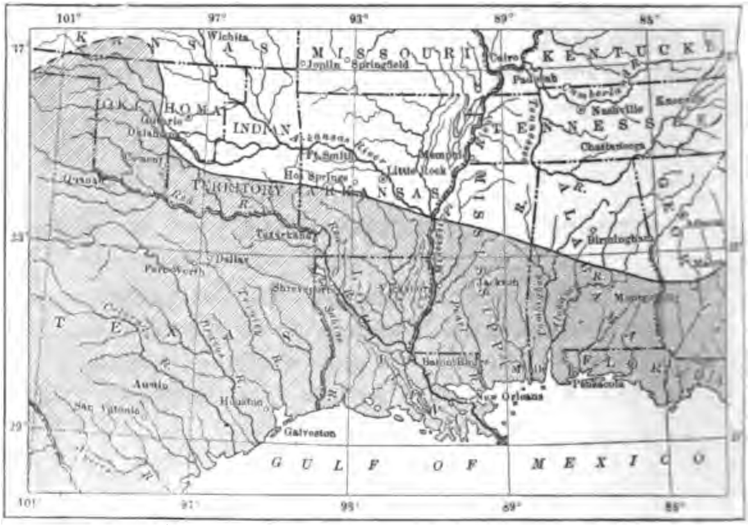


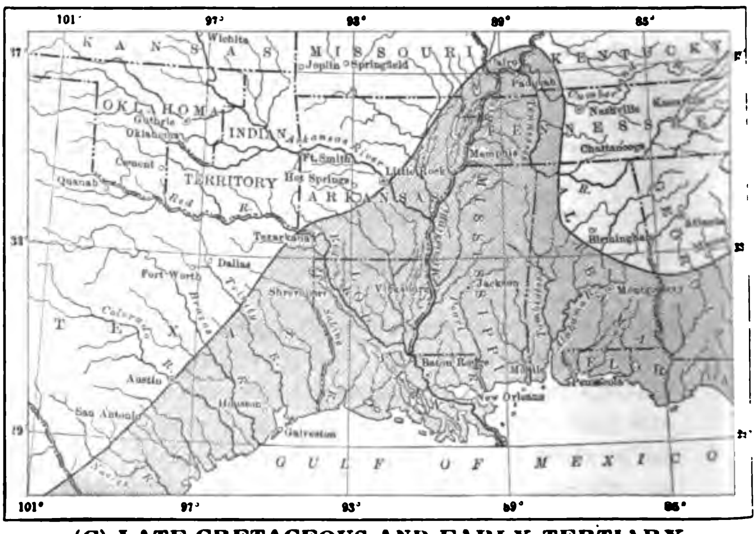
FIG. 19.—Cross section at Drakes Salt Works, Louisiana, showing locationof shallow brine wells and symmetrical truncated character of dome.

Whether the forces producing these unique domes were in any way associated with those producing intrusions farther north it is as yet impossible to say; but the irregularity of their distribution, the great symmetry of all the domes which have been carefully studied[3], the difficulty of explaining this symmetry by any manner of folding not associated with igneous intrusions, and the suggestion which this symmetry carries of force applied at

[3] See Veatch, A. C., The salines of northern Louisiana: Geol. Survey Louisiana, Rept. of 1902, pp. 41-100; Pls. XVIII-XXII.



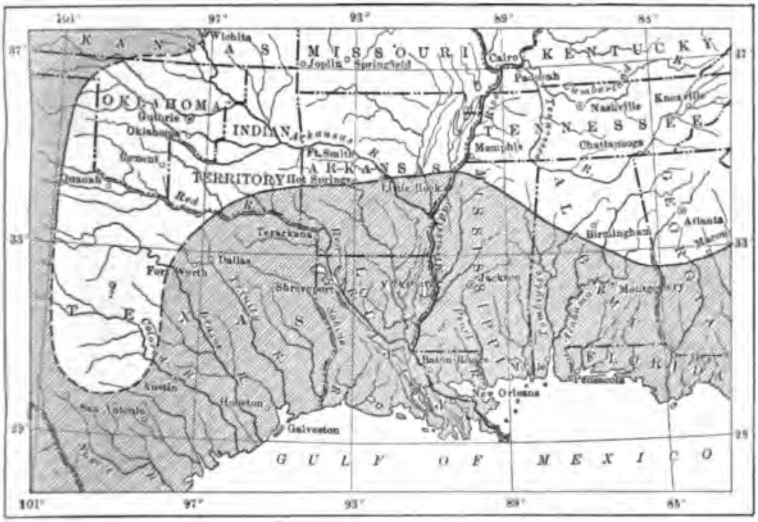
(A) EARLY LOWER CRETACEOUS



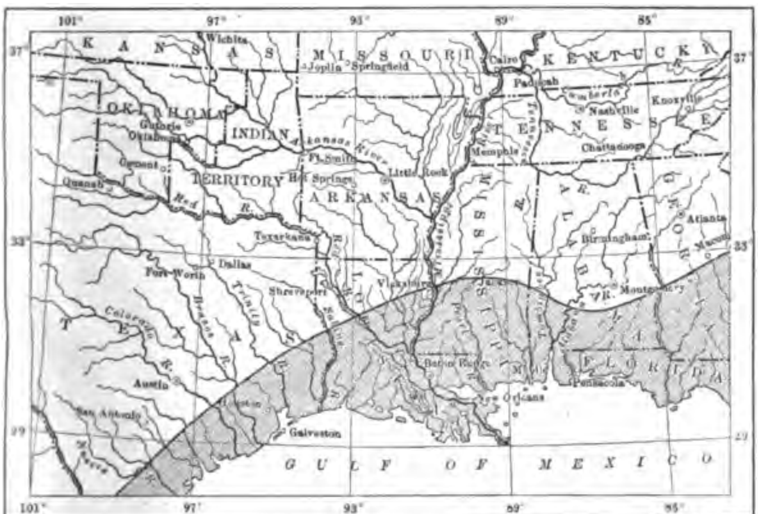
(C) LATE CRETACEOUS AND EARLY TERTIARY

100 0 100

Relative positions of land and water areas in the south-central U. S
and all shaded areas. Land: Unshaded portions of present land.



(B) EARLY UPPER CRETACEOUS



(D) EARLY OLIGOCENE TERTIARY

ale 200 400 600 800 MILES

uring the Cretaceous Tertiary epochs. Water: Present Gulf of Mexico

one point from below, just as a sharp-pointed little dome might be formed in a sheet of dough by pushing upward with a blunt pencil, indicate similar igneous intrusions beneath these great thicknesses of relatively plastic, recently deposited Cretaceous sediments as the cause of these domes.[4]

Whatever their true origin, the sea floor showed, near the close of the Cretaceous, or in the early Tertiary, a series of steep-sided, more or less circular elevations. These elevations would naturally modify the conditions existing in the portions of the sea where they were sufficiently contiguous to materially interrupt the oceanic circulation, and it is perhaps to such an interruption by the Texas group of domes that the salt deposits of Grand Saline, Tex., are due.

These domes were entirely buried by the Eocene sediments, and as the twelve which have thus far been found in northern Louisiana and eastern Texas (Pl. XXXVII) all occur in valleys (Pls. XXVII, XXXVIII, sec. F) flanked by hills of Tertiary strata and their exposure is due to more or less accidental conditions of erosion, it is quite probable that others will be encountered when the country is more thoroughly prospected. This probability introduces a decided element of uncertainty into the artesian-well prospects of this region.

In determining the amount of deformation represented it is necessary to ascertain with some degree of accuracy the age or stratigraphic position of the beds exposed in these domes. At the Anderson[5] and Brooks[6] salines in Texas and at the Bisteneau, Kings, and Rayburns salt works in Louisiana[7] fossil shells, such as *Exogyra costata*, *Gryphæa vesicularis*,[8] *Ostrea* larva, and other forms representing an uppermost Cretaceous fauna, have been found in limestone or chalk-marl deposits. These beds are the

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[4] See footnote p.66.

[5] Dumble, E. T., Second Ann. Rept. Geol. Survey Texas, 1891, pp. 304, 305.

[6] Herndon, J. H., Second Ann. Rept. Geol. Survey Texas, 1891, p. 223.

[7] Veatch, A. C., Geol. Survey Louisiana, Rept. of 1902 [1902], pp. 73, 74, 78, 86–87.

[8] The variety which Taff figures as characteristic, in Arkansas, of the base of the Saratoga or mid-Marlbrook formation: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pls., 51, 52.

lithologic and paleontologic counterparts of the Marlbrook division of the Arkansas section, and may be tentatively referred to it. If of Marlbrook age the displacement to the present top of the dome is 1,100 feet (Pl. XXXVIII, sec. D) The original height of the top of the dome is not known, but the present truncated top is 1¼ miles in diameter, and the removed portion must have had a thickness of many hundred feet. The known displacement at Kings and Rayburns is about the same, but the total displacement was probably somewhat less, as is indicated by the smaller area of their truncated tops.

The beds exposed in the Winnfield dome are nonfossiliferous, light-colored, porous crystalline limestone in which the cavities are filled with sharp calcite crystals. Similar porous limestones of great thickness have been encountered in wells at Drakes (904, 994) and Cedar Lick, two miles south of Winnfield (999), and as the structure in all these cases is the same as that at the localities carrying Cretaceous fossils, and as the limestones are totally different from any of the Tertiary sediments in this region, they are regarded as Cretaceous deposits which have been altered by the pressure and heat produced in forming the domes. These marbles could not have been formed from any of the beds above the Marlbrook, and they are therefore regarded as Marlbrook or older. The deformation represented is therefore in the neighborhood of 2,000 feet (Pl. XXXVIII, sec. C).

At Coochie Brake, Drakes, and Prices Salt Works very arenaceous limestones, containing leaf impressions, are found in the domed areas. These, if Cretaceous—and it is difficult to see how they may be Tertiary—represent either the Nacatoch or the Bingen. At Drakes the diameter of the truncated dome is about a mile, and the observed angle of slope on one side is 45°. This indicates that the strata removed may have had a thickness of as much as 2,000 feet and that the total deformation may be 3,000 or 4,000 feet.

The deformation at the Many dome, which is capped with Midway limestone, is almost the total thickness of the Sabine in this region, or between 800 and 1,000 feet.

The greater part of the movements represented in these domes took place in late Cretaceous or early Tertiary time, certainly

before the deposition of the Sabine sediments, which show no signs of deformation of this magnitude. However, it seems probable that these points have been the loci of slight movements since that time, and that the relatively great dip of the Claiborne beds immediately surrounding the Winnfield dome is due to such a slight movement rather than entirely to deposition on a highly inclined surface.

TERTIARY

EOCENE

CONDITIONS OF DEPOSITION

The change from the Cretaceous to the Tertiary in this region is much more of a paleontologic than a stratigraphic break; many of the genera and all of the species of mollusks inhabiting the Cretaceous sea disappeared at the close of the Cretaceous, as if by magic, to be replaced by the entirely new fauna which inhabited the Eocene ocean.

No stratigraphic break at all commensurate with the paleontologic break has been discovered in this region, and the abrupt change in the animal life is, as Dana suggests,[9] perhaps due more to an alteration in the direction and character of the ocean currents, with the consequent change in temperature and food supply, and to the destructive effects of earthquake waves resulting from the gigantic disturbances which produced the Rocky Mountains, than to a time lapse.

Midway epoch.—Certainly the earliest Eocene deposits, the Midway formation, are sediments indicating depths and distribution of water which are but the normal continuation of the Cretaceous conditions to which cycle of deposition they seem more properly to belong. This fact, with the presence of the Midway on the top of two of the domes, at Kings and Many, suggests that the domes were formed as late as the beginning of the Sabine.

The shore line of this early Eocene ocean was roughly parallel to that of the late Cretaceous sea, and the slight deepening of the water which permitted the formation of the Midway limestone,

[9] Manual of Geology, 4th ed., 1895, pp. 877–878.

together with a slight warping, allowed the ocean to advance farther up the Mississippi embayment than before, and made possible the deposition of marine fossils in southern Illinois,[10] while marine Cretaceous fossils have not been found north of northern Tennesee.[11]

Sabine epoch.—The Mississippi embayment at this time was relatively shallow and flat-bottomed—its present depth of perhaps 3,000 feet at Memphis being the result of very gradual warping accompanied by a deposition which kept pace with the lowering and which extended through the whole Eocene—and a slight elevation was sufficient to convert it into a great low-lying swamp, or marsh, occasionally submerged by the ocean. The conditions were favorable for the growth of shallow-water marine mollusca only as far north as Sabine Parish in Louisiana, about 30° north latitude, and in eastern Alabama about the latitude of Meridian, Miss., and even here there was an alternation of marine near-shore and swampy conditions. These deposits constitute the Sabine formation. Above these swamps, or out of the shallow-water sea, the domes projected as a unique series of circular hills, and as the progressive subsidence continued they were gradually buried beneath the swamp, estuarine, and shallow-water marine deposits, doubtless undergoing in the process more or less erosion from atmospheric agencies and ocean waves.

Claiborne epoch.—A slight depression, or perhaps it would be better to say a slight excess of the rate of depression over the rate of sedimentation, in eastern Texas and along the embayment caused the marine fauna to extend farther northward and to reach in the embayment region a point a little north of the thirty-third parallel. Still farther north, where the water was not deep enough, or river sediments prevented the growth of marine forms, the deposition of the lignitiferous sands and clays containing no marine fossils, which had begun at the close of the Midway, continued. A slight elevation, greater in Louisiana and Texas than

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[10] Worthen, Geol. Survey Illinois, vol. 1, 1856, pp. 44-46; Loughridge, Geol. Survey Kentucky, Rept. on Jackson's Purchase Region, 1888. pp. 41-52; Harris, Geol. Survey Louisiana, Rept. of 1902 [1902], p. 9.

[11] Loughridge, Geol. Survey Kentucky, Rept. on Jackson's Purchase Region, 1888, p. 32.

in Alabama, converted the shallow, flat sea bottom of the early portion of the Claiborne epoch into a coastal or estuarine marsh, and in western Mississippi, Louisiana and Texas from 200 to 500 feet of lignitiferous clays and sands with no marine fossils were laid down before the gradual oscillation of this region or changes in climatic conditions again permitted a northward transgression of the marine fauna. This group of sediments is called the Cockfield member of the Claiborne.

Jackson epoch.—Following the Cockfield deposition, conditions were favorable for the growth of marine forms to a point somewhat north of Memphis. This, the Jackson epoch, completed the main filling of the embayment area.

In the succeeding Oligocene and Miocene time the shore line retreated gulfward, and there is no evidence that during these ages there was more than a gentle curve in the coast line in the region of the old Mississippi embayment (Pl. XXVI, D).

MAJOR DIVISIONS OF THE EOCENE

The Eocene about latitude 31° 30′ north is composed of the following major paleontologic subdivisions: (1) The Midway, characterized by fossiliferous limestone, but containing some blue clay; (2) the Sabine, composed of lignitiferous sands and clays, with marine fossils in the seaward or southern portions; (3) the Claiborne, composed of very fossiliferous calcareous clay in its lower portion and lignitiferous sands and clays, with no marine fossils, in its upper (Cockfield member); and (4) the Jackson, composed of fossiliferous calcareous clays. In the upper portion of the embayment all the beds become lignitiferous and lose to a greater or less extent their distinctive marine fossils. This lignitiferous complex, which can be separated only on purely stratigraphic grounds, is discussed and mapped in this report as "undifferentiated Eocene" (p. 35).

MIDWAY FORMATION [12]

This formation, which was named by Smith and Johnson in 1887 from a landing on the west side of the Alabama River in

[12] Synonymy of the Midway formation:
≡ Midway stage, Harris (Bull. Am. Pal., vol. 1, 1896, pp. 11-13).
≡ Midwayan stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey 1898, table opp. p. 334.

Wilcox County, Ala.,[13] and redefined by Harris[14] to include a paleontologic group bounded below by the Cretaceous and above by the Nanafalia beds of the Sabine (Lignitic), has been traced more or less intermittently along the southern edge of the Cretaceous outcrops—or where they are missing, as in the uppermost and western parts of the Mississippi embayment, along the Paleozoic rocks—from Georgia to Colorado River in Texas and perhaps to the Rio Grande.

As already indicated, its lithologic characters are more similar to the underlying calcareous Cretaceous clays and marls than to the overlying lignitiferous beds of the Sabine. Although this formation is composed of irregularly bedded dark-colored calcareous clays with more or less sand, it is generally characterized by the absence of the lignitic material so common in the overlying Sabine formation and by a bed or beds of impure white limestone 10 to 25 feet thick, which, because of its lithologic resemblance, was for a long time correlated with the Cretaceous. In common with other beds of the Eocene, it contains *Venericardia planicosta*,

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=Basal or Wills Point clays, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 19-22).

≡Midway (or Clayton)+Sucarnochee or Black Bluff+Naheola or Matthews Landing, Smith *et al.* (Bull. U.S. Geol. Survey No. 43, 1887, p.18; Geology of the Coastal Plain of Alabama Geol. Survey Alabama, 1894, p. 27).

>Porter Creek group, Safford (Am. Jour. Sci., 2d ser., vol. 37, 1864, p.368).

>Flatwoods clays, Hilgard (Agriculture and Geology of Mississippi, 1860, pp. 110, 111: Proc. Am. Assoc, Adv. Sci., vol. 20, 1871, p. 222; Am. Jour. Sci.,3d ser., vol. 2, 1871, p. 391).

=Middleton formation, Safford (Bull. Geol. Soc. America, vol. 3, 1892, pp. 511, 512).

NOTE.—In this and the several syononym tables following, the symbols used have the following meanings:

≡Equal to in every respect.

=Equal in a general way.

>Less than.

<Greater than.

≠Not equal to.

[13]Bull. U. S. Geol. Survey No. 43, 1887, p. 62.

[14]Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, pp. 8, 9, 22; Bull. Am. Pal., vol. 1, 1896, pp. 11-13.

Pseudoliva vetusta, and forms of *Calyptraphorus velatus* and *Turritella mortoni*. Among other forms which are peculiar to this formation and which are, therefore, marks of identification are *Enclimotoceras ulrichi* White, *Ostrea crenulimarginata* Gabb, *Ostrea pulaskansis* Harris, and *Volutilithes limopsis* Conrad.[15]

In Arkansas the Midway limestone outcrops along the edge of the Paleozoic rocks from Bayou Departe, Independence County, to below Rockport, on Ouachita River near Malvern, Hot Springs County (Pl. XXVII). It is particularly well developed around and south of Little Rock, where the total thickness of the beds exposed is not known to be greater than 20 feet. Between the outcrops near Malvern and southwestern Travis County, Tex., no exposures are known, but from the latter point southward to Brazos River the limestone and marls form a narrow belt having a maximum width of 13 miles near Wills Point.[16] The total thickness in this section is estimated by Kennedy at 260 feet,[17] which is but a little greater than that found in this formation in western Alabama by Harris (210 feet).[18] It therefore seems probable that the thickness of the Midway beds underlying Louisiana is about 200 feet.

In Louisiana limited outcrops of the Midway have been found in connection with two of the domes, Many and Kings (Pl. XXVII), and the report of "*Nautilus dekayi* Morton" (probably *Enclimotoceras ulrichi* White) between Hendersons Mills and Albany, in Caddo Parish,[19] together with the irregularity of the

[15] For a detailed discussion of the paleontology of the Midway formation see Harris, G. D., The Midway stage: Bull. Am. Pal., vol. 1, 1896, pp. 117-270.

[16] Kennedy, William, Proc. Philadelphia Acad. Nat. Sci. for 1895, 1896, pp. 144-149.

[17] Third Ann. Rept. Geol. Survey Texas, 1892, p. 49.

[18] Harris, G. D., Bull. Am. Pal., vol. 1, 1896, p. 145.

[19] Collins, H. C., Ann. Rept. Chief of Engineers for 1873, vol. 1, 1873, pp. 651–654; also House Ex. Doc., 43 Cong., 1st sess., vol. 2, pt. 2, 1873, pp. 651–664. A careful examination of this locality by the writer failed to confirm this report. Collins' statement, however, bears so many earmarks of careful observations faithfully recorded, that the results of this examination are not felt to be conclusive.

section of a well sunk near the mouth of Cottonwood Bayou, which obtained brine, suggests that there may be another dome area in this region (Pl. XXXVIII, sec. F). None of the fossils have been examined, but it seems probable from the structure of the region that the shell marls reported in wells at Uni (835, 836) and at Furrh, La. (802), are Midway, as are likewise the shells found in the well at Waldo, Ark., (Pl. XXXVIII, secs. F, H, I).

SABINE FORMATION[20]

Overlying the Midway limestones and calcareous clays is a series of dark, finely laminated sands and clays containing much vegetable matter, either scattered through the mass or accumulated in lignite beds, and occasional layers containing marine shells. It commonly differs from the underlying Midway in the

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[20] Synonymy of the Sabine formation:

≡Lignitic stage, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304; Bull. Am. Pal., vol. 2, No. 9, 1897).

≡Chickasawan stage, Dall (not Hilgard) (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, table opp. p. 334).

<Lignitic, Smith *et al.* (Bull. U. S. Geol. Survey No. 43, 1887, pp. 18, 38; Geol. Survey Alabama, Bull. No. 2, 1892, p. 47; Geology of Coastal Plain of Alabama, Alabama Geol. Survey, 1894, pp. 147, 198, 488), which includes the Midway.

>Mansfield group, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, p. 340), which includes all the Sabine formation except the fossiliferous beds.

<Mansfield group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 78, 83), which includes the nonfossiliferous portion of the Sabine and the Claiborne (Cockfield).

<Camden series, Hill (Geol. Survey Arkansas, Rept. for 1888, vol. 2, 1888, pp. 49-53), which includes fossiliferous Jackson, the Lagrange, and a portion of the Cretaceous.

>Lignitic, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, p. 50; Proc. Philadelphia Acad. Sci. for 1895, 1896, p. 92), which includes all the Sabine except the fossiliferous beds.

<Lagrange group, Safford (Am. Jour. Sci. 2d ser., vol. 37, 1864, pp. 369-370; Rept. Memphis Waterworks for 1898), which includes portions of all the Eocene beds above the Midway.

<Timber belt or Sabine River beds, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 22-47, 117), which in eastern Texas included also the lower Claiborne, Cockfield, and Jackson.

presence of lignitic material and fossil leaves and when containing marine fossils is readily distinguished from both the Midway and the overlying Claiborne. Toward the coast, where it is overlain by the very calcareous, argillaceous, fossiliferous lower Claiborne beds, its upper limit can be fixed with exactness, but farther inland, where estuarine and swamp conditions persisted until Jackson time, no separation is possible except on a purely stratigraphic basis. (See Pl. XXXVIII).

On the whole, the formation is predominantly sandy, and while the sand beds are not so regular or so coarse as some of the beds in the Cretaceous, they are the most important water-bearing strata in Louisiana and Arkansas north of the outcrop of the Catahoula formation (Pl. XXVII), and south of the Eocene-Cretaceous boundary.

In Alabama this formation, which has long been called the Lignitic, contains several fossiliferous horizons that are closely related from a paleontologic standpoint, but show faunal differences which have led to the recognition of four substages, named as follows, beginning with the lowest: (1) Nanafalia, (2) Bells and Greggs Landing (Tuscahoma), (3) Woods Bluff, and (4) Hatchetigbee. The first two are sometimes collectively called the Bells Landing substage and the second two the Bashi substage.[21] No distinctive marine fossils have yet been found in the lignitiferous time equivalents of this formation in Mississippi, Arkansas, and the upper embayment region, but along Sabine River in Louisiana and Texas, in the same position relative to the embayment as the Alabama deposits, are developed fossiliferous beds showing the same facies. *Ostrea thirsæ*, an oyster common in the Nanafalia horizon in Alabama, occurs in abundance at Marthaville, La., and the fossils from Pendleton and Sabinetown bluffs on Sabine River, in Sabine County, Tex., show very close affinities to the Greggs Landing and Woods Bluff horizons of Alabama.[22] These beds are limited above by a well-

[21] Smith, E. A., and Johnson, L. C., Bull. U. S. Geol. Survey, No. 43, 1887, p. 18; Smith, E. A., Johnson, L. C., and Langdon, D. W., Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, p. 27; Harris, G. D., Bull. Am. Pal., vol. 2, 1897, p. 196.

[22] Harris, G. D., Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 65-72, 299-309; Geol. Survey Louisiana, Rept. of 1902, pp. 123-125.

preserved and abundant lower Claiborne fauna, and below by the Midway (Wills Point) fossiliferous clays and limestones.

The name Lignitic formation, derived from the lithologic character of the beds, is not in accordance with the rules of geologic nomenclature, and it is therefore necessary to give to this formation the name of some locality at or near which the beds are typically exposed. As the name Chickasaw formation[23] or stage, which has been used by Dall as an exact synonym for Lignitic, is neither stratigraphically nor historically appropriate in this sense, and as the name Lagrange (Safford, 1864), has been applied to the lignitiferous complex above the Midway, and as the doubtful definition and the lack of marine fossils at the type localities of the Mansfield group (Hilgard, 1873) and Camden formation (Hill, 1888) make them unavailable, the name Sabine has been suggested and adopted, from the typical development of the formation along Sabine River in Sabine County, Tex., and Sabine Parish, La., and from noteworthy exposures at Sabinetown Bluff.

The Sabine formation and its equivalent beds in the undifferentiated Eocene underlie the whole of Louisiana, except the limited areas occupied by the outcrops of the Cretaceous and Midway

[23] This name was suggested by Hilgard as an appropriate equivalent for his Northern Lignitic (which is defined in Geology of Mississippi, 1860, pp. 110-123; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp. 394-396), for the very sufficient reason that the "entire Northern Lignitic is within the Chickasaw Purchase, and its most characteristic and conspicuous outcrops are on the four Chickasaw bluffs, of which the Memphis bluff is the last" (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 344-345). Dall, however, assumed that Hilgard's Northern Lignitic was the exact equivalent of the Lignitic defined by paleozoologic criteria in the Alabama section, and so used it. As a matter of fact the Northern Lignitic is a lignitiferous complex, containing representatives of all the beds between the Midway and the Jackson (see p. 33), and therefore represents the swamp and estuarine deposits of the Sabine, Claiborne, and Jackson epochs. The strata exposed in the Chickasaw bluff, the type locality (see Pl. XXXVIII A,) are stratigraphically either Jackson or the underlying Cockfield, which is uppermost Claiborne. In the whole of the Chickasaw Purchase (about 20,000 square miles) no locality of the Sabine (Lignitic) containing typical marine fossils has been found, and it is necessary to go 100 miles from its border for such a locality. It therefore appears necessary either to use the name Chickasaw formation in the sense in which Hilgard defined it or to abandon it.

domes, and all of Arkansas south and east of the Cretaceous and Midway outcrops (Pl. XXVII). Its thickness, as shown by carefully constructed sections in which local irregularities are reduced to their proper minor importance, ranges from 300 feet in northern Bossier Parish to from 800 to 900 feet near Natchitoches and on Sabine River (Pl. XXXVIII).

CLAIBORNE FORMATION [24]

This formation, which overlies the Sabine, contains the most persistent and widely developed marine beds of the Coastal Plain, and is known to extend from Maryland to the Rio Grande. Its extremely fossiliferous character early attracted attention, and it was from collections from Claiborne Bluff, on Alabama River, in Alabama, that the presence of beds of Eocene age in the Gulf States was first proved by Conrad.[25] He named it the Claiborne formation and, with Lea,[26] described and figured many of the fossils found in a relatively thin sand bed which outcrops in the bluff at Claiborne Landing, Ala. Subsequent work has shown that this bed, which is generally referred to as the Claiborne sand, is but a very local development, paleontologically, of one of the larger divisions of the Eocene. It is to this large division that the name Claiborne formation or Claiborne group is now applied. (See synonymy.)

In central Louisiana the Claiborne formation is divisible into a lower fossiliferous member, which has been called the "Lower Claiborne" in this area, and an upper lignitiferous member, called the Cockfield, which contains no marine fossils. The lower portion is much more calcareous, glauconitic, and clayey than the underlying Sabine beds, and where typically developed contains no lignitic nor lignitiferous matter, though to the north it changes to lignitiferous sands and clays and merges into the undifferentiated Eocene group. Thus, while across San Augustine and Sabine counties, Tex., and on Sabine River it is extremely calcareous and fossiliferous and is sharply limited both above and

[24] Synonymy of the Claiborne formation:
=Claibornian stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 342-343), except the White Bluff beds.

below by the lignitiferous beds of the Cockfield and the Sabine, and while it maintains this calcareous, fossiliferous character northward in Louisiana to about the Vicksburg, Shreveport and Pacific Railway (Pl. XXVII), yet north of that line the beds are pronouncedly lignitiferous in character. A few small, poorly preserved Claiborne fossils have been found in northern Bossier Parish,[27] and stratigraphic relations suggest that the fossils

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=Claiborne (sand)+Lower Claiborne, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304), except the White Bluff beds.

≡Claiborne sand+*Ostrea sellæformis* beds+Lisbon beds+Buhrstone, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304).

≡Claiborne (sand)+Buhrstone, Smith and Johnson (Bull. U. S. Geol. Survey No. 43, 1887, p. 18).

≡Claiborne proper (including the Claiborne sand and *Ostrea sellæformis* beds)+Buhrstone, Smith, Johnson, and Langdon (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 27, 122, 124, geologic map of Alabama, 1894).

>or=Claiborne stage or Claiborne group (siliceous Claiborne+calcareous Claiborne), Hilgard (Geology of Mississippi, 1860, pp. 108, 123-128).

>Claibornian, Heilprin (Proc. Philadelphia Acad. Nat. Sci., 1882, p. 184; Contributions to Tertiary geology and palentology of the United States, Philadelphia, 1884, p. 30), which is exactly equivalent to Claiborne sand.

<Lower Claiborne, Kennedy (Proc. Philadelphia, Acad. Nat. Sci. for 1895, p. 92), which includes portions of Jackson and basal Oligocene beds.

<and>Cooks Mountain beds+Mount Selman beds (Marine deposits or Marine beds), Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, p. 45; Bull. U. S. Geol. Survey No. 212, pl. 2, 1903), which include also the portion of the Sabine which contains marine fossils.

=Lower Claiborne+Cockfield Ferry beds, Vaughan (Bull. U. S. Geol. Survey No. 142, 1896, p. 21).

=Lower Claiborne, Harris and Veatch (Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 73–89, geologic map).

=Lower Claiborne+Cockfield, Harris (Geol. Survey Louisiana, Rept. of 1902 [1902], pp. 17-21).

[25] Conrad, T. A., Eocene fossils of the Claiborne, with observations on this formation in the United States: Fossil Shells of the Tertiary Formation of North America, vol. 1. No. 3, 1835, pp. 29-36. (See Harris's republication of Conrad's Fossil Shells, 1893, pp. 75-84).

[26] Lea, Isaac, Tertiary formation of Alabama: Contributions to Geology, Philadelphia, 1833, pp. 9-209, pls. 1-6.

found in the wells at Buckner, Ark., and Dubach, La. (889), and at Walnut Bluff, below Camden, on Ouachita River,[28] are also Claiborne, but the general character of the beds in this region indicates nearshore or swamp conditions very different from the deeper water conditions farther south.

In Louisiana and Texas the commonest and most readily recognized fossils of this formation are *Ostrea sellæformis* and *Anomia ephippoides*. The oysters are particularly abundant, often forming "oyster prairies," which are bald spots covered with oysters.

The thickness of this lower fossiliferous portion of the Claiborne formation is 250 to 300 feet in the region about Monroe, but increases to over 500 feet at Winnfield. On Sabine River the thickness, calculated from dip observations, is 550 feet,[29] and the section of a well recently put down near Robinsons Ferry which obtained fossils at a depth of 1,250 feet, that Dr. W. H. Dall regards as Claiborne, indicates that it is as much as 700 feet.

COCKFIELD MEMBER OF THE CLAIBORNE[30]

The lignitiferous sands and clays which occur in central Louisiana between the marine portions of the Claiborne and Jackson formations are extremely similar in lithologic character to the Sabine beds, and were at first confused with them. They contain no marine mollusks and are characterized by thin, impure lignite beds and clays, often containing plant remains in an excellent state of preservation. They are identical in appearance with the lignitiferous complex to the north (undifferen-

[27] Harris, G. D., Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, pp. 178–180.

[28] Ibid., pp. 141–142.

[29] Geol. Survey Louisiana, Rept. 1902, p. 120.

[30] Synonymy of the Cockfield member:

=Upper Lignitic beds, Lerch (Preliminary report on the hills of Louisiana south of the Vicksburg, Shreveport and Pacific Railway to Alexandria, 1893, pp. 82–85).

≡Cockfield Ferry beds, Vaughan (Am. Geol., vol. 15, 1895, p. 220; Bull. U. S. Geol. Survey No. 142, 1896, p. 21).

<Lower Claiborne, Harris and Veatch (Geol. Survey Louisiana, Rept. 1899 [1900], pp. 80–82), which includes also the fossiliferous portion of the Claiborne in Louisiana.

tiated Eocene) of which they form a part, and can be definitely differentiated only when fixed between fossiliferous Claiborne and Jackson beds or by structural data.

They were first definitely separated from the other Eocene nonmarine strata by Lerch, who called them the upper Lignitic in distinction from the lower Lignitic (Sabine) which occurred below the lower Claiborne formation. Later Vaughan found these beds typically exposed at Cockfield Ferry,[31] on Red River, halfway between the very fossiliferous Claiborne beds at St. Maurice and the Jackson beds at Montgomery, and named them the "Cocksfield Ferry beds."

At Jackson, Miss., the Cockfield beds have a thickness of about 400 feet.[32] In Louisiana the thickness ranges from 400 to 500 feet. (See Pl. XXXVIII.)

≡Cockfield beds, Harris (Geol. Survey Louisiana, Rept. of 1902 [1902], p. 21.

≡Cockfield Ferry beds or Cocksfield, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 130–131, 141, 158, 160–163).

=?Yégua, Dumble (Report on Brown Coal, Geol. Survey Texas, 1892, pp. 148-154; Science, new ser., vol. 16, 1902, pp. 670–671).

<Yégua clays, Kennedy (Proc. Philadelphia Acad. Nat. Sci., vol. 47, 1895, p. 92), which includes part of the fossiliferous marine Jackson.

<Lufkin or Angelina County beds, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, pp. 45, 58–60), which includes part of the fossiliferous marine Jackson.

<Mansfield group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 78–83), which includes the unfossiliferous Sabine.

<Northern Lignitic, Hilgard (Geology of Mississippi, 1860, pp. 110-123; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp, 394-396), which includes also lignitiferous portions of the Sabine and lower Claiborne.

[31] This was spelled by Vaughan "Cocksfield Ferry." The maps of the Red River Survey (MS. sheet No. 37, Red River Survey, U.S. Eng'rs., 1889-1890, scale 1 : 10,000) gave two plantations at this point belonging to "A. P. Cockfield" and "W. J. Cockfield." The ferry name should naturally be spelled in the same way as the name of the owners. The section at "Cocksfield Ferry," published by Vaughan (Am. Geol., vol. 15, 1895, pl. 9; Bull. U. S. Geol. Survey No. 142, 1896, pl. 1), is really a section of Petite Ecore, or, as it has been improperly anglicized, "Petite Ecore Bluff."

[32] Based on well section given in Geology and Agriculture of Mississippi, 1860, p. 191.

The sandy, near-shore character of these beds makes them of greater importance as water carriers than the Claiborne and Jackson. In central Louisiana they commonly contain great amounts of soluble salts and the water is generally not so good as that from the Sabine. In Arkansas and Mississippi a sand bed at about the same stratigraphic position as the basal Cockfield water horizon yields good potable water.

Regarding the relation of the Cockfield to the Jackson and Claiborne time divisions the data at hand, as has been pointed out by Vaughan,[33] indicate that they are late Claiborne rather than early Jackson. In central Louisiana they are limited below, at St. Maurice, by fossils which belong low in the Claiborne, and above, at Montgomery, by fossils, which, while not basal Jackson, are low in the Jackson; and while the Cockfield may contain a small amount of the Jackson, it is to be regarded as almost wholly of Claiborne age. In southern Arkansas, where basal Jackson fossils are developed, the Cockfield is clearly of Claiborne age. In central Texas, as pointed out by Dumble,[34] the Yégua of Dumble (not Kennedy) presents many points of resemblance to the Cockfield, and is here clearly a portion of the Claiborne.

JACKSON FORMATION[35]

The Jackson group was named by Conrad[36] in 1856, from

[33] Bull. U. S. Geol. Survey No. 142, 1896, p. 22.

[34] Science, new ser., vol. 16, 1902, pp. 670–671.

[35] Synonymy of the Jackson formation:

- =Jacksonian stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, p. 342.
- =Jackson stage, Harris and Veatch (Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 89–93; Geol. Survey Louisiana, Rept. of 1902, pp. 22–23, 131–132, 141, 158, 164–167).
- <Jackson group, Hopkins (Second Ann. Rept. Geol. Survey Louisiana, 1871, pp. 7–15, map), which includes the Sabine, Cockfield, lower Claiborne, and a part of the Jackson; the remainder of the Jackson is included in his Vicksburg group.
- <White limestone, Johnson (Report on the iron region of northern Louisiana and eastern Texas; House Ex. Doc., 50th Cong. 1st sess. No. 195, 1888, map, pp. 14–15), which includes lower Claiborne (in part), Cockfield, Jackson, and Vicksburg (?).
- <Yégua clays, Kennedy (Proc. Philadelphia Acad. Nat. Sci. vol. 47, 1895, p. 92), which includes the Cockfield.

Jackson, the capital of Mississippi, where the beds are typically exposed. It consists of a series of fossiliferous, somewhat gypseous, calcareous clays which have been traced from eastern Alabama to eastern Texas. It extends farther up the Mississippi embayment than any other of the Tertiary beds containing marine fossils except the Midway, having been found in wells at Hays Landing, La. (872), near Arkansas City, Ark. (144), and at Helena, Ark. (644). It is exposed at Crowleys Ridge, west of Memphis, and, south of Arkansas River in Arkansas, extends from near Little Rock to Hamburg. (See Pls. XXVII and XXXVIII, sec. A). At Crowleys Ridge it shows a marked tendency to change into lignitiferous clays—a tendency which is quite like that of the Claiborne and the Sabine farther south.

In this region it is the most fossiliferous marine bed of the Eocene, with the possible exception of the Claiborne in Louisiana and the Midway in Arkansas, from both of which it may be distinguished by its characteristic fossils and stratigraphic position. One of the noted outcrops in Louisiana is shown in Pl. XXVIII.

≠Yégua, Dumble (Report on Brown Coal, Geol. Survey Texas, 1892, pp. 148–154; Science, new ser., vol. 16, 1902, pp. 670–671), which is regarded as a portion of the Claiborne.

<White limestone, Smith (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 107, 232, 376, 492, 495; see also Casey, Proc. Philadelphia Acad. Nat. Sci. for 1901, 1901, pp. 513-518).

<Fayette sands, Kennedy (Proc. Philadelphia Acad. Nat. Sci. for 1895, 1896, pp. 92, 95–99; Bull. U. S. Geol. Survey No. 212, 1903, p. 20, pl. 2). These, as defined by Kennedy, are largely Catahoula (Grand Gulf), but include, near the base, Jackson fossils. (See Harris, Geol. Survey Louisiana, Rept. of 1902, p. 25; Veatch, ibid., p. 133).

<Vicksburg, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, pp. 340–341; Supplement and Final Report of a Geological Reconnaissance of Louisiana, New Orleans, 1873, pp. 18–19), which includes all the Jackson and Claiborne beds in Louisiana along Sabine River and a number of Jackson localities in eastern Louisiana.

≠Jackson group, Lerch (The hills of Louisiana south of the Vicksburg, Shreveport and Pacific Railway [1893], pp. 88–91), which includes only a portion of the lower Claiborne.

[36] Conrad, T. A., Proc. Philadelphia Acad. Nat. Sci., vol. 7, 1856, p. 257.

NOTED FOSSILIFEROUS JACKSON OUTCROP AT MONTGOMERY, LA.

UNDIFFERENTIATED EOCENE [37]

The Eocene beds, which in central Louisiana, Mississippi and Alabama are fossiliferous, all become lignitiferous in the upper portion of the embayment. The marine fossils of the Sabine, lower Claiborne, and Jackson epochs each extend farther northward than those of the preceding epochs, but in each case the beds bearing marine fossils grade into lignitiferous clays and sands containing no distinctive marine fossils.

The first name given to this lignitiferous group, which can not be separated except on structural grounds, was the Lagrange. This included all the Eocene beds in Tennessee above the Midway, and was afterwards quite logically extended by its author, Prof. J. M. Safford, State geologist of Tennessee, to include the lignitiferous sands and clays of Crowleys Ridge,[38] which are of

[37] Synonymy of the undifferentiated Eocene:

=Northern lignitic, Hilgard (Geology of Mississippi, 1860 pp. 110–123; Am. Jour. Sci., 3d ser,, vol. 2, 1871, pp. 394–396), except the Flatwoods clays, which are Midway.

≡Lagrange, including Bluff lignite, Safford (Am. Jour. Sci., 2d ser., vol. 37, 1864, pp. 369–370).

≡Lagrange+Bluff lignite, Safford (Geology of Tennessee, 1869, pp. 424–428).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, 1874, Taintor Brothers, New York, publishers).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, Tavel, Eastman & Howell, Nashville, Tenn., 1875).

≡Lagrange, Safford and Killbrew (Elementary Geology of Tennessee, Nashville, 1876, pp. 165–166).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, 1888, 1896, 1899).

≡Lagrange, Safford (Rept. Memphis Water Works, 1898, p. 16).

≡Lagrange, Safford (Elements of the Geology of Tennessee, Nashville, 1900, pp. 104, 160–161).

<Camden series, Hill (Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 188–189), which includes the Jackson and a portion of the Cretaceous.

=(?)or>Camden beds, Hill (Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 188–189).

>Chickasaw stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 344–345), which is restricted to the Lignitic (Harris, 1894) or Sabine formation.

[38] Lundie, John, Rept. on Waterworks System of Memphis, Tenn., 1898, p. 16.

lower Jackson age and are the stratigraphic equivalents of the beds in the upper Chickasaw Bluffs. This formation grows more sandy to the north, where at Memphis essentially continuous sand beds 800 feet thick have been penetrated.[39]

OLIGOCENE

CONDITIONS OF DEPOSITION

The change from the Eocene to the Oligocene in this area is, like the change from the Cretaceous to the Eocene, much more a paleontologic than a stratigraphic break, and while beds of lignitiferous strata separate the Jackson from the basal Oligocene or Vicksburg beds, they are of no greater importance as an indication of a time break than half a dozen beds within the Eocene. No pronounced unconformity or discordance of the strata has been observed. However, such characteristic and abundant Eocene forms as *Venericardia*, *Pseudoliva*, *Volutilithes*, and *Calyptraphorus* abruptly terminate in the Jackson, and are replaced in the basal Oligocene by a distinctly different fauna. Of the 122 species known in the basal Oligocene, but 10 are found in the Claiborne and Jackson.[40]

The lowest Oligocene beds in the Mississippi Valley, like the basal Eocene, are lithologically more like the topmost beds of the preceding series than the succeeding beds of the larger time division which they initiate. They represent conditions of deposition and distribution of ocean water which are but the continuation of those of the previous period, while the succeeding beds are indicative of more or less radical changes. The basal Oligocene beds, the Vicksburg formation, are overlain by near-shore deposits consisting of coarse sandstones interstratified with greenish-gray clays very different from the underlying calcareous and lignitiferous strata and entirely devoid of marine remains, though containing land plants and fresh-water shells. This group of beds, which is called the Catahoula formation, is in turn overlain by greenish calcareous clays, containing a very few

[39] Safford, J. M., Bulletin State Board of Health, vol. 5, pt. 7, Feb. 20, 1890, pp. 98–106 ; Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2, 1891, pp. 28–29.

[40] Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553.

VICKSBURG LIMESTONE, MINT SPRING BAYOU, JUST ABOVE VICKSBURG, MISS.

brackish-water shells and called the Fleming formation. Indeed, if physical rather than biological changes were made the basis of the broader geologic divisions, the dividing lines between the Cretaceous and Eocene and the Eocene and Oligocene in this region would be drawn above the base of the deposits of these larger time units.

During the Eocene the Mississippi embayment was almost, if not completely, filled, and in the Oligocene, except possibly in early Vicksburg time, the coast line was a simple broad curve reaching from eastern Georgia to Mexico with no pronounced indentations (Pl. XXVI D).

VICKSBURG FORMATION [41]

The Vicksburg formation, which was named by Conrad in 1846[42] from its very fossiliferous exposure in the bluffs at Vicksburg, Miss. (Pl XXIX), where it has a total thickness of 120 feet,[43] is the lithological counterpart of the underlying Jackson, from which it can be distinguished by its characteristic fossils. The

[41] Synonymy of the Vicksburg formation:

≡ Vicksburg, Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553).

≠ Vicksburg, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, pp. 340–341; Supplemental and Final Report of a Geological Reconnaissance of Louisiana, New Orleans, 1873, pp. 18–19). All the localities at which Hilgard reported Vicksburg in Louisiana have proved to be Claiborne or Jackson.

< Vicksburg group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 94–98; Second Ann. Rept. Geol. Survey Louisiana, 1870, 1871, pp. 15–18). Includes portions of the Claiborne and Jackson.

≠ White limestone, Johnson (Iron Region of Northern Louisiana and Eastern Texas, 1888, pp. 14–16). As described, this includes only Jackson and Claiborne fossils.

< St. Stephens White limestone, Smith (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 107, 232, 376, 492, 495), which includes the Jackson. According to Casey, it has not yet been definitely proved that the White limestones contain any true Vicksburg (Proc. Philadelphia Acad. Nat. Sci. for 1901, pp. 513–518).

[42] Conrad, T. A., Proc., Philadelphia Acad. Nat. Sci., vol. 3, 1846, pp. 280–281.

[43] Hilgard, E. W., Am. Jour. Sci. 3d ser., vol. 2, 1871, map facing p. 391.

known extent of the typical Vicksburg is very limited. West of Mississippi River it has been definitely proved to occur only in a limited region in northern Catahoula Parish, La.[44] (Pl. XXVII), though it may extend westward to the vicinity of Little River. To the east certain beds in eastern Mississippi and Alabama, particularly the great Orbitoidal limestone of the Florida peninsula, have been correlated with this formation, but the recent work of Dall[45] renders this correlation somewhat doubtful, and Casey has suggested that the true Vicksburg beds represent but a local development in a remnant of the old Mississippi embayment.[46]

CATAHOULA FORMATION[47]

Overlying the fossiliferous Vicksburg clays and limestones is a series of sandstones and greenish clays which are generally quite

[44] The outcrops of the Vicksburg beds 3 miles south of Rosefield were first described by Hopkins, who correctly referred them to the Vicksburg (First Ann. Rept. Geol. Survey Louisiana for 1869, 1870, p. 97; Second Ann. Rept. Geol. Survey Louisiana for 1870, 1871, p. 16). They were, however, first definitely proved to belong to this stage by Vaughan (Bull. U. S. Geol. Survey No. 142, 1896, p. 52).

[45] Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553.

[46] Casey, T. L., On the probable age of the Alabama White limestone; Proc. Philadelphia Acad. Nat. Sci. for 1901, pp. 513-518.

[47] Synonymy of the Catahoula formation:

<Grand Gulf sandstone, Wailes (Agriculture and Geology of Mississippi, 1857, pp. 216–219). Includes typical Grand Gulf sandstone and (erroneously) some consolidated Claiborne and Lafayette.

<Grand Gulf group, Hilgard (Report on Geology and Agriculture of Mississippi, 1860, pp. 147–154), which includes the Catahoula, Fleming, and Pascagoula formations.

=Typical Grand Gulf, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, table facing p. 334).

≡Grand Gulf proper, Harris (Geol. Survey Louisiana, Rept. of 1902, p. 28).

<Grand Gulf beds, Harris (ibid.).

≡Grand Gulf, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 132–135).

<Fayette beds, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 47–58), which are a composite including Claiborne beds in their type locality and Catahoula and Fleming beds in east Texas.

≠Fayette beds, Dumble (Jour. Geol., vol 2, 1894, pp. 552–554; Science, new ser., vol. 16, 1902, p. 671), which are Claiborne.

From U. S. Geol. Surv. Photograph by G. D. Harris

ON TEXAS AND PACIFIC RAILWAY, NEAR LENA, LA.

different, lithologically, from any of the older beds of the Tertiary series in Louisiana and Arkansas. The sandstones which are the characteristic feature of this formation range in thickness from a few inches to 50 or 60 feet (Pl. XXX, wells 859, 938, 939), and thickness of as much as 140 feet (well 855) have been reported.[48] These sand beds are often cemented by silica into very hard quartzites, but such occurrences are essentially local, and the quartzitic beds pass laterally in very short distances into soft sandstones or even unconsolidated sands. These sandstones and quartzitic layers have resisted erosion more than the underlying clays and unconsolidated sands of the Eocene and so have formed a line of rocky hills, the Kisatchie Wold (Pl. XXV), extending across Louisiana, into Texas on the one hand and into Mississippi on the other.

These beds contain no indications of marine life, but land plants are abundant and fresh-water shells have been found in several places. The change from the conditions existing in the Vicksburg is very marked and indicates an elevation during which the region where the oceanic conditions were favorable for the growth of marine life was considerably south of the present outcrop of the formation (see Pl. XXVII).

These beds were observed at Grand Gulf, on Mississippi River, in Claiborne County, Miss., by Wailes, the first State geologist of Mississippi, who referred to them as the "Grand Gulf sandstones."[49] Later Hilgard[50] used the name "Grand Gulf group" to include the beds exposed in southern Mississippi between the Vicksburg and the relatively recent coastal clays (Port Hudson),

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< Fayette sands, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, pp. 60-62; Bull. U. S. Geol. Survey No. 212, 1903, pp. 20, 21-22), which includes a portion of the Jackson. (See Geol. Survey Louisiana, Rept. of 1902, pp. 25, 132-133.)

= Oakville, Dumble (Science, new ser, vol. 16, 1902, pp. 670-671). This correlation, while suggestive, needs further evidence to verify it.

[48] Kennedy, William, Third Ann. Rept. Geol. Survey, Texas, 1892, p. 63.

[49] Wailes, B. C. L., Agriculture and Geology of Mississippi, 1857, pp. 216-219.

[50] Hilgard, E. W., Rept. on Agriculture and Geology of Mississippi, 1860, pp. 147-154.

and the name has been used with varying shades of meaning by different authors since that time.[51]

In view of this confusion and in order to furnish a name not likely to be misunderstood, the name Catahoula formation is used in this paper as a synonym for the "typical Grand Gulf" or the "Grand Gulf proper." This new name is from Catahoula Parish, La.,[52] which is directly across the Mississippi Valley from Grand Gulf and where there are many outcrops which are lithologically and stratigraphically counterparts of the beds of the old type locality. From this place the beds have been traced eastward through Mississippi into Alabama, where they apparently grade into a series of fossiliferous sands and calcareous clays known as the "Chattahoochee group." To the west they extend in a very pronounced line across Louisiana into eastern Texas, and, according to Dumble, are continued across that State in his Oakville beds.[53] The thickness of this formation, as shown by comparative cross sections based on wells at Alexandria (933, 939) and Boyce (944) and on dip observations on Sabine River,[54] is about 1,100 feet (Pl. XXXVIII).

The country in which this formation outcrops is, as a rule, poor in everything but long-leaf pine. The sand beds are, however, important water carriers, and in places (as near Harrisonburg, Lena, and Christie, La., and about Rockland, Tex.) the quartzitic layers have been quarried for riprap work and ballast (Pl. XXIV).

FLEMING CLAY[55]

The Fleming clay, which was so named by Kennedy in 1892[56] from Fleming siding on the Missouri, Kansas and Texas Railway

[51] In this connection see the following; Smith, E. A., and Aldrich, T. H., Science, new ser., vol. 16, 1902, pp. 835–837; Idem, vol. 18, 1903, pp. 20–26; Dall, W. H., Science, new ser., vol. 16, 1902, pp. 946–947; Idem, vol. 18, 1903, pp. 83–85; Hilgard, E. W., Science, new ser., vol. 18, 1903, pp. 180–182.

[52] It may be of historic interest to note that one of the first mentions of the outcrops of this formation refers to the exposures at Catahoula shoals, in Catahoula Parish, which were even at that early day correctly correlated with the exposures east of the Mississippi (see Darby, William, A Geological Description of the State of Louisiana, Philadelphia, 1816, pp. 45–46).

[53] Science, new ser., vol. 16, 1902, pp. 670–671.

[54] Geol. Survey Louisiana, Rept. of 1902, pp. 120, 132–135. pl. 37.

[55] Synonymy of Fleming clay:

near the line between Tyler and Polk counties, Tex., consists of green or bluish green calcareous clays, differing from the underlying Catahoula beds in the presence of numerous small white calcareous nodules and the absence of the characteristic Catahoula sandstone layers. Near its base it often contains a bed of bright-red clay, which forms a convenient line of parting.[57] These beds produce a stiff, heavy soil that is often black and resembles the soils of the Cretaceous prairies. Except where deeply covered with the surficial sands and gravels, these are commonly quite distinct from the coarse, sandy soils of the Catahoula formation.

Although these deposits represent less truly littoral sediments than the Catahoula beds, extended search has failed to reveal any marine remains except near Burkville, Newton County, Tex., where a brackish-water Oligocene fauna [58] has been found in a local development of limestone 3 to 4 inches thick. These beds are particularly well developed on Neches River in the vicinity of Townbluff and extend east and west from that point in a belt 5 to 15 miles wide.

The thickness of the Fleming beds is not well known, though

=Fleming beds, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1891, pp. 62–63).

≠Frio clays, Dumble (Jour. Geol., vol. 2, 1894, pp. 554–555; Science, new ser., vol. 16, 1902, pp. 670–671), which are regarded as Claiborne.

≡Frio clays, Kennedy (Proc. Acad. Nat. Sci. Philadelphia for 1895, 1896, pp. 93–95; Bull, U. S. Geol. Survey No. 212, 1903, pp. 20, 22–23, pl. 2).

≡Frio Clays, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 135–137, 141–144, pl. 37).

≡Frio clays, Harris (Geol. Survey Louisiana, Rept. of 1902, pp. 28–32).

≡Frio clays, Maury (Bull. Am. Pal., vol. 3, 1902, pp. 353, 390, pl. 25).

[56] Kennedy, W., Third Ann. Rept. Geol. Survey Texas, 1892, pp. 62–63.

[57] Ibid., p. 63; Harris, G. D., Geol. Survey Louisiana, Rept. of 1902, p. 31.

[58] Geol. Survey Louisiana, Rept. of 1902, p. 136; Bull. Am. Pal., No. 15, vol. 3, 1902, p. 80. Kennedy (Bull. U. S. Geol. Survey No. 212, 1903, p. 53) reports a number of lower Claiborne (Eocene) species from this locality, but the collection made by the writer in 1902, which was by far the largest made at this point, showed none of the species listed by Kennedy. Dr. T. W. Vaughan l ter visited the outcrop and states that the fragmentary material which he was able to obtain was regarded by both himself and Dr. W. H. Dall as having a decidedly Oligocene aspect.

it has been estimated by Kennedy at 260 feet and by Veatch at 200 + feet.[59]

Along Sabine River the dip of the Fleming formation is much less than that of the basal Catahoula beds, though it is apparently the same as that of the uppermost Catahoula, which is from 25 to 35 feet per mile.

MIOCENE AND EARLY PLIOCENE

After the deposition of the Fleming beds a general elevation of this region, accentuated locally by the further development of the low Angelina-Caldwell monoclinal flexure (Pl. XXXVII), caused the sea to retreat southward to a point between the present outcrop of the Catahoula and Fleming formations and the Gulf shore. This retreat was but one of the steps in the gradual growth of this portion of the American continent, which, with minor retrogressions, such as occurred in the late Pliocene, has resulted in moving the shore line of the southern sea, now the Gulf of Mexico, from a line, as yet unfixed, north of the southern edge of the Ouachita Mountains to the present coast.

The effect of this late Oligocene, Miocene, and early Pliocene uplift and the very slow and gradual tilting which accompanied it was to permit the formation in the coast region of Louisiana of very thick post-Oligocene deposits, which, with the beds that were formed in the late Pliocene and Quaternary, have a thickness in that region of much more than 3,000 feet.[60] The region north of this shore line was by this elevation subjected to more or less profound erosion, by which this new Coastal Plain, underlain by Oligocene, Eocene, and Cretaceous sediments, was reduced to a level, in Louisiana and Arkansas, of from 500 to 700 feet above the present sea level. North of this Coastal Plain, in the region of the older rocks, where erosion had been active since the first arching and tilting of the great Jurassic peneplain in the

[59] Geol. Survey Louisiana, Rept. of 1902, p. 120.

[60] The Galveston, Tex., well at a depth of 2,920 feet reached only the upper part of the Miocene (Harris, Fourth Ann. Rept. Geol. Survey Texas, for 1892, 1893, p. 118; Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pp. 402–406).

early Cretaceous, the erosion of the Miocene and early Pliocene completed the formation of a plain lying below the level of the old Jurassic peneplain and containing many protruding remnants of the older surface. This lower, partially developed Tertiary peneplain was essentially continuous with the eroded Coastal Plain.

LATE PLIOCENE

LAFAYETTE FORMATION

CONDITIONS OF DEPOSITION

In the late Pliocene a considerable change in elevation occurred, which caused the sea to advance from its position a little north of the present Gulf coast and to cover much of the eroded Coastal Plain and in places to extend over the bordering rocks. The sea, in its advance and retreat, spread over this plain a sheet of littoral deposits, and the rivers flowing into it filled up the valleys with similar materials.

This great blanket of silts, sands, and gravels of near-shore and fluviatile origin, which, from its exposures in Lafayette County, Miss., has been named the Lafayette formation by Hilgard,[61] and which has been described at length by McGee,[62] was, in northern Louisiana and southern Arkansas, largely worn away and redeposited in the succeeding periods of erosion. Its remnants or redeposited remnants are, however, very common throughout the Coastal Plain in Arkansas and Louisiana, though the exact relation of the different deposits and the succession of events involved in their redeposition can be exactly determined only by a very detailed study after large-scale topographic maps have been prepared.

PRESENT DISTRIBUTION

South of the Catahoula and Fleming formations these sands and gravels form the surface for miles and then pass southward beneath the more recent clays of the Quaternary (fig. 20), forming there the water-bearing beds which furnish a portion of the

[61] Hilgard, E. W., Am. Geol., vol. 8, 1891, p. 130.

[62] McGee, W. J., The Lafayette formation; Twelfth Ann. Rept. U. S. Geol. Survey, pt. 1, 1891, pp. 347-521.

waters used in the irrigation of that region. North of the Catahoula sandstone their occurrence is essentially fragmentary, and they appear and disappear in an extremely irregular manner. As shown by wells, they are commonly thickest in the large valleys, where they have been concentrated by erosion subsequent to their original deposition, but they do not normally outcrop on the surface of the present river flood plains and on the adjoining terraces, though they are frequently exposed in the base of the river banks at low water and are generally abundant where the terraces grade into the adjacent hills.

They are notably absent in regions of very calcareous clays, as in the Jackson area in Louisiana and the regions underlain by the more calcareous beds of the Cretaceous,[63] a peculiarity of distribution due to two factors: (1) The clayey

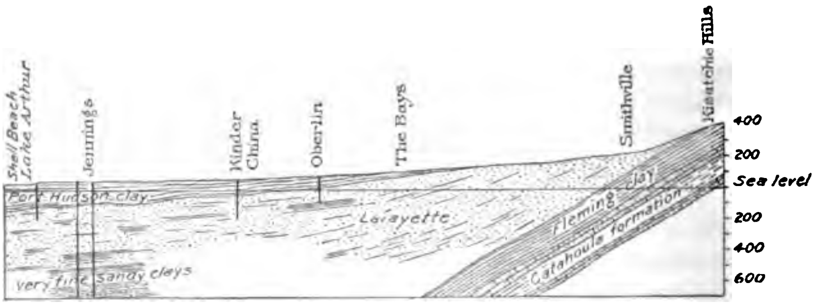


FIG. 20.—North-south section showing Lafayette and younger gravels passing beneath the clays of the Port Hudson and supplying artesian wells in southern Louisiana.

layers of a gently sloping unconsolidated Coastal Plain series are generally more easily eroded than the sandy beds, and the surficial beds are therefore really more completely removed along the outcrops of the clay layers; (2) it is not always possible to state positively that these Lafayette and younger beds are absent from the weathered outcrops of the sandy layers of the older Coastal Plain series, and it often happens, because of the absence of pronounced lithologic differences, that the Lafayette beds are

[63] Also observed in Mississippi and Alabama (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, p. 63; Agriculture and Geology of Mississippi, 1860, p. 5; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 105–106).

assumed to be present in great thickness, when in fact they are almost or entirely absent. Thus, in Arkansas, portions of the weathered outcrops of the Bingen and Nacatoch sands[64] have been mistaken for these surficial beds. Outcrops of a bed of littoral sediments, probably Cretaceous, lying below the Midway at Little Rock,[65] and ferruginous deposits in Louisiana belonging to the lower Claiborne[66] have also been improperly classed as Lafayette.

The gravel deposits are particularly abundant along Ouachita and Little Missouri rivers, and on the eastern side of the old course of Red River, along Bayou Dorcheat and Black Bayou. The bowlders along this line are often of extreme size; thus at Bisteneau Salt Works large masses of quartzite, containing 8 to 10 cubic feet, were observed in 1899 and were then thought to be local,[67] but similar bowlders have subsequently been found at many points to the north between this locality and the novaculite outcrops in the Ouachita Mountains. Similar bowlders have been found on Ouachita River near Monroe[68], and it is difficult, in the absence of any known glacial action, to imagine how they could have been transported 100 to 150 miles from their source, unless it were by floating ice. Call, however, has made the suggestion that somewhat similar bowlders on Crowleys Ridge were carried by roots of floating trees.[69] This, while possible in some cases, is not believed to be the true explanation of all the occurrences observed in southern Arkansas and northern Louisiana. These large gravel deposits belong more properly to the period of erosion and readjustment which followed the Lafayette than to the Lafayette submergence itself.

[64] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 28-42, map; Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pl. 47.

[65] Twelfth Ann. Rept. U. S. Geol. Survey, pt. 1, 1891, p. 470; Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, p. 7.

[66] Second Ann. Rept. Geol. Survey Louisiana for 1870, 1871, pp. 22–23; Bull. Louisiana State Exper. Sta.; Preliminary report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific Railway, 1893, pp. 24-26; Bull. U. S. Geol. Survey No. 142, 1896, pp. 20-22; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 100–101.

[67] Geol. Survey Louisiana, Rept. of 1902, p. 88.

[68] Ibid., p. 169.

[69] Call, R. E., Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2.

QUATERNARY

PLEISTOCENE

LATE TERTIARY AND EARLY QUATERNARY EROSION

A gradual elevation marked the close of the Lafayette epoch and the sea retreated southward over the deposits laid down in its former advance, reassorted them, and carried back into the ocean some of the finer materials of the upper layers. The streams following the sea across this newly emerged coastal plain, in courses determined by its slight irregularities, began at once to trench its surface and incidentally to form the major topographic features of to-day. As this slow elevation continued the streams cut deeper and deeper into the underlying beds and, while at first the valleys were deep and narrow and the major streams were separated by large flat-topped areas representing the old plain level, the tributary streams gradually wore back into these level regions, divided them, and carved them into hills. When at last the land came to rest, at a height of about 100 feet above the present level, the streams, unable to cut below the very low slopes necessary to carry their waters seaward, began to cut from side to side and in time made broad valleys somewhat larger than the present flood plains, which occupy the depressions produced by these older rivers, but which are now restricted by the unremoved portions of the Port Hudson deposits forming terraces. The bottom lands along the larger streams, the ancient Mississippi, Arkansas, Ouachita, and Red rivers, were about 100 feet below the present flood plains (see bottom of gravel layer, (Pl. XXXVIII,) and like the latter were trenched still deeper by the streams traversing them (see stream cuts in present destructional flood plains, shown in fig. 23), p. 51). Thus the bed of the Mississippi of today has an extreme depth of 150 feet below its banks at Vicksburg, 165 feet at Fort Adams, and 175 feet 4 miles below the mouth of Red River,[70] and the abnormal depths of the redeposited Lafayette and Quaternary materials encountered in some of the wells given in the following tables are, in part, thought to be due to such occurrences, though they may be the effect of a slight uplift toward the close of this erosion period.

[70] Mississippi River Comm., Survey of Mississippi River, charts Nos. 48, 60 and 61.

Table showing thickness of Port Hudson and redeposited Lafayette and Quaternary beds in the Red River Valley, and indicating the position of the old land surface.

Well No.[71]	Location	Thickness of deposits
	LOUISIANA	
	Bossier Parish:	*Feet.*
788	Lake Point	120
783	Bossier City (3 miles north of)	130
784	Bossier City (2½ miles north of)	76
785	Bossier City	80
786	Bossier City	195?
794	Pool	111?
	Caddo Parish:	
803	Missionary	130
796	Belcher	96
797	Belcher (3 miles northeast of)	125
799	Dixie	60
800	Dixie (2½ miles east of)	85
801	Dixie (3 miles southwest of)	121
835	Uni	70
804	Below Shreveport	69–110
805	Robson	106
832	Bayou Pierre	70
	Natchitoches Parish:	
906	Luella	300?
908	Montrose	180
	Grant Parish:	
877	Colfax	130
	Rapides Parish:	
953	Rapides (average of 5 wells)	108
937	Alexandria	90
938	Alexandria	155
940	Alexandria	110+
950	Pineville	200?
950	Pineville	230?
947	Lamothe	105+

Table showing thickness of Port Hudson and redeposited Lafayette beds in the Mississippi Valley, and indicating the position of the old land surface

Well No.[72]	Location	Thickness of deposits
	LOUISIANA	*Feet.*
873	Lake Providence	248?
872	Hays Landing	109
894	Mound	135+
922	Monroe	95
923	Monroe	80
867	Fish Pond	145+

[71] Numbers correspond to those used in Chapter V.

[72] Numbers correspond to those used in Chapter V.

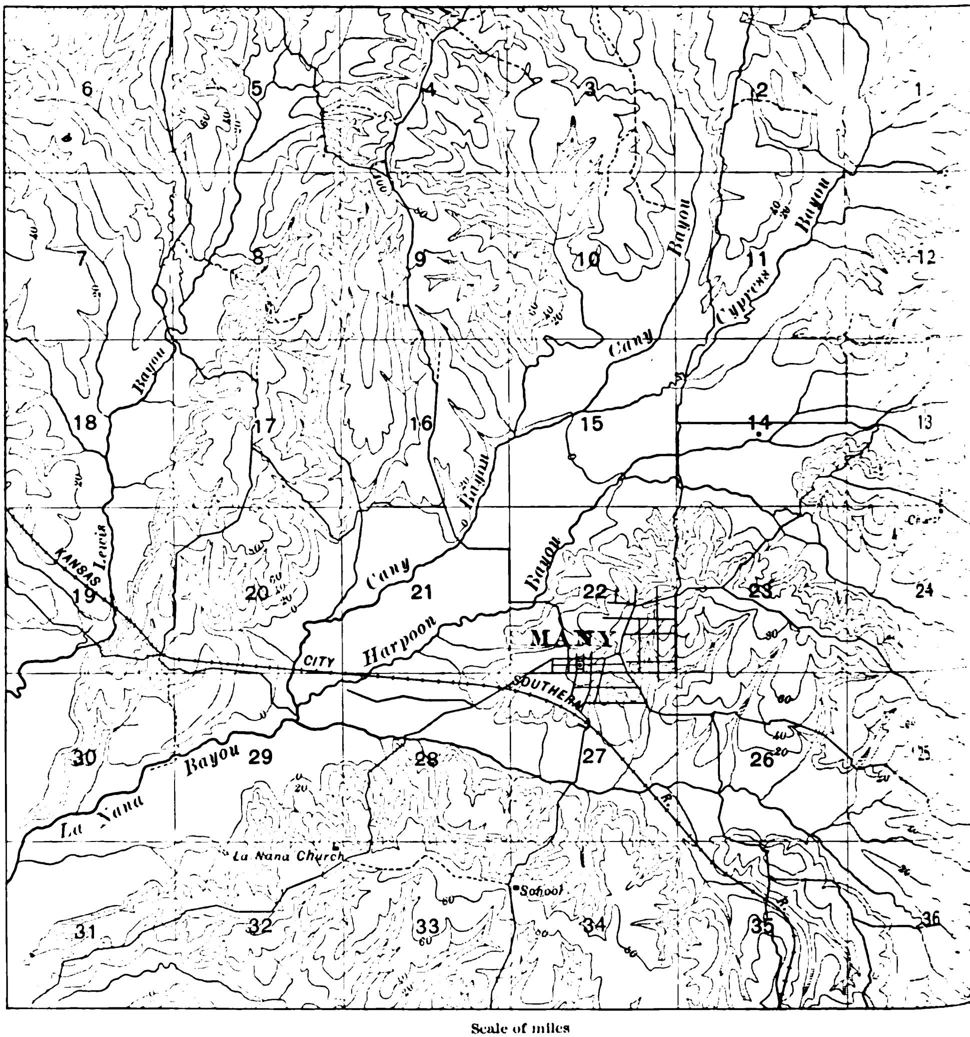
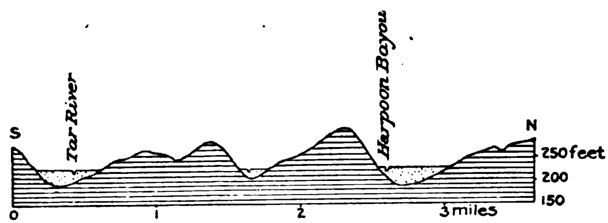


FIG. 21.—Sketch topographic map near Many, Sabine Parish, La., showing the characteristic flat-bottomed, stee- small stream valleys of northern Louisiana and southern Arkansas, by A. C. Veatch, 1899.

In the area between the main streams the tributaries formed in time an interlocking drainage very little different from that of to-day, and at the close of this long period of erosion almost all of the old plain level had been destroyed (Pl. xxv) and the major topographic features of northern Louisiana and southern Arkansas produced. Indeed, the only great difference between the topography of that day and this was that the principal valleys were 100 to 150 feet deeper, and the Port Hudson terraces (Pl. XXVII) were entirely absent. The valleys of the small streams did not then show their present anomalous, steep sided, flat-bottomed, filled character (fig. 21), but the hill slopes passed in curves of gradually lessening gradient to the streams between them (fig. 22). The topographic features of to-day are but the features developed in that period, slightly modified by the partial filling of the valleys in the succeeding period of low level and the incomplete re-excavation of this filling which has taken place since that time.



From U. S. Geol. Surv.

FIG. 22.—Section near Many, La., showing typical flat-bottomed, filled character of small stream valleys in northern Louisiana and southern Arkansas; also showing typical steeper gradient of north-facing than of south-facing hill slopes.

PORT HUDSON DEPOSITION

CONDITIONS OF DEPOSITION

During the long preceding period, which in its results was essentially one of erosion, though there were doubtless many stages that have not yet been interpreted, the mantle of Lafayette sands and gravels was largely worn away and redeposited. The gravel was concentrated at many points by stream action and toward the close of the period, when perhaps the land stood slightly higher than before, and when the Mississippi may have been augmented by glacial flood waters, many of the valley bottoms were covered with sand and gravel.

With the slow subsidence which then began the carrying power of the streams was diminished and the gravels were covered with fine sands and, in time, with silts and clays. The bottom lands were converted into great low-lying swamps and mingled with the deposits formed at this time. In the valleys north of Baton Rouge are fresh-water shells[73] and many swamp-loving trees, as well as driftwood washed in from the higher lands.

These swamp deposits and their accompanying blue clays are succeeded by silty or sandy, somewhat calcareous clays, which reflect the general character of the sediments of the rivers along which they are found. Thus, on the Mississippi they are yellow or grayish yellow and contain numerous ferruginous and a few calcareous concretions, while on Red River they are bright red and contain many lime nodules not vastly different from those found in the loess and known as "loesskindchen."

These deposits are to-day best exposed in the riverward edges of the terraces. Along the Mississippi excellent exposures are found in the railroad cuts near Hamburg and in the Morehouse and Avoyelles hills (Pl. XXXI), while on Red River notable outcrops are found at St. Andres Bluff, near Colfax; at Campti; at Red Bluff, east of Frierson; on the Kansas City Southern Railway, north of Wallace, Cross, and Ferry lakes; in Caddo Parish; at Red Bluff, near Bodcau; at Hurricane Bluffs, in Bossier Parish;[74] and at Fulton and Mandeville, on the St. Louis, Iron Mountain and Southern Railway, in Arkansas (Pl. XXVII).

Occasionally some of the large animals which then lived in this portion of the country wandered into these marshes and became mired. Among the bones preserved in this way are species of the *Mastodon*, and *Elephas*, of the *Mylodon*, *Megalonyx*, *Megatherium*, and *Glyptodon*, large animals akin to the sloths, and armadillos, now found in South America, a camel, a large elk, and a prehistoric horse but little different from the domestic horse of today.

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[73] Third Ann. Rept. Geol. Survey Louisiana for 1871, 1872, p. 177; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 190–191.

[74] See Geol. Survey Louisiana, Rept. for 1899 [1900] pp. 113–114, 189–192; Third Ann. Rept. Geol. Survey Louisiana, for 1871, 1872, pp. 185–190.

From U. S. Geol. Surv.

ESCARPMENT ON THE SOUTHERN EDGE OF THE MARKSVILLE HILLS.

A Port Hudson terrace in Avoyelles Parish, La.

These deposits are all essentially fluviatile or estuarine in origin, and the present level tops of their remnants, which form terraces along the sides of the principal valleys (fig. 23), indicate that this depression was not over 100 feet below the present level. On Red River the height of the terraces is seldom over 60 feet above the present bottom lands, and in the Mississippi Valley, near the Arkansas-Louisiana State line, it ranges from 60 to 80 feet. To the north the terraces become lower, and in southeastern Missouri they have an elevation of but 20 to 30 feet,[75] a variation which is perhaps due to recent movements either along the line of the Angelina-Caldwell flexure, the Red River-Alabama Landing fault, or both (Pl. XXXVII).

These clay terrace

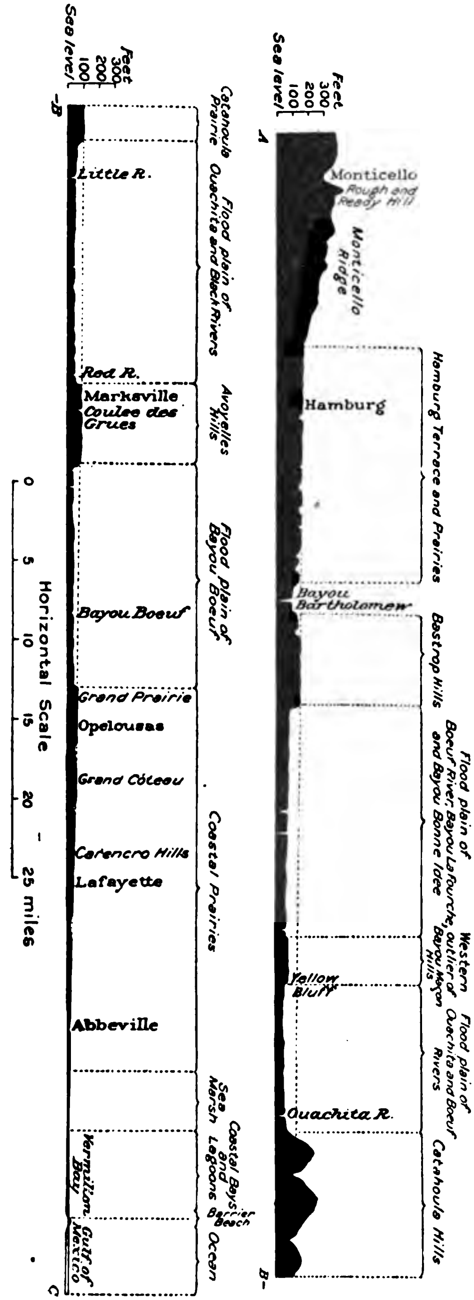


FIG. 23.—Section from Monticello, Ark., to the Gulf of Mexico, near Abbeville, La., showing the relation of the Hamburg terrace, Bastrop Hills, Catahoula Prairie, and Avoyelles Hills to the coastal prairies.
From U. S. Geol. Surv.

[75] Marbut, C. F., Univ. of Missouri Studies, vol. 1, No. 3, 1902, p 16.

deposits are continued southward in the pine meadows of eastern Louisiana and the prairie and pine flats of southwestern Louisiana, which are doubtless of the same age. The hills which border the Bayou Teche, the Grand Coteau des Opelousas, and the Cote Gelee, represent the eastern scarp of this prairie region where it has been cut by the Mississippi. They are but the southern representatives of the isolated terrace remnant, the Avoyelles Hills, which is the connecting link between them and the Mississippi and Red River terraces (fig. 23). With the exception of the present sea marsh and the inconsiderable alluvial deposits of the present Mississippi flood plain, these coastal prairies are the most recent deposits of southern Louisiana above sea level.

DEPOSITION OF THE LOESS

Near the close of this low-level period great floods of water from the glaciers to the north brought down large quantities of very fine yellow rock meal. This is now found capping the highest hills east of the Mississippi as far south as the Mississippi-Louisiana State line and west of the Mississippi, in Arkansas and Louisiana, only on Crowleys Ridge, and at Sicily Island. It was early recognized at Vicksburg by Lyell and by him correlated with similar deposits in the Rhine Valley called "loess."[76] By some it is thought to represent the natural levees of an immensely swollen Mississippi, but the hypothesis best supported by the known facts is that it was deposited by glacial flood waters over the Mississippi plain and formed great mud flats, from which after drying, it was conveyed to its present position by the wind.[77]

EROSION OF THE PORT HUDSON DEPOSITS

With the elevation that followed the Port Hudson period of low-level the main streams began to cut out the deposits which partially filled their valleys. This erosion which was the last of the major stages in the formation of the present topography, has

[76] Lyell, Charles, Second visit to the United States, 1849, vol. 2, pp. 194-195.

[77] For an excellent summary of this question see Chamberlain, T. C., Jour. Geol. vol. 5, 1897, pp. 795-802.

resulted in the partial removal of the Port Hudson deposits, which in northern Louisiana and southern Arkansas are now found as terraces along the sides and underlying the present flood plains at no very great depth.[78] The nearness of the Port Hudson sediments to the surface and the relative thinness of the present alluvial deposits indicate that the flood plains of all the larger rivers of this area, except, perhaps, the Mississippi plain below Donaldsonville and New Orleans are to be regarded, on the whole, as destructional rather than constructional plains.

The amount of erosion accomplished in post-Port Hudson time is very small when compared with that accomplished in the long and complex late Tertiary and early Quaternary period of erosion, when the main topographic features of this region were produced.

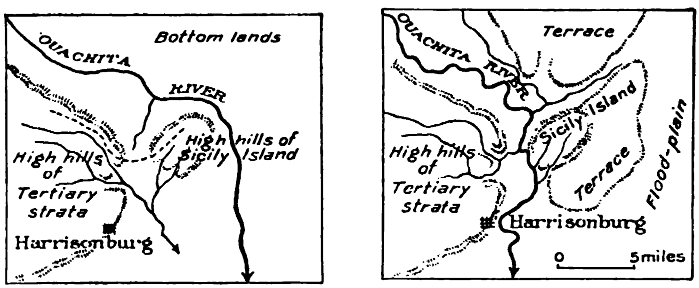
To the south the plain, which was continuous with the Opelousas Hills and low bluffs along the Mississippi near Baton Rouge and which formed an integral part of the prairies and pine flats of Louisiana, was broadly trenched leaving these bluffs on either side to indicate its former height and extent. In central Louisiana the Avoyelles Hills were separated, on the one hand, from the Opelousas Hills by a broad valley, formerly the flood plain of Red River, but now occupied by Bayou Boeuf (fig. 23), and, on the other hand, from the terraces to the northwest, whose edge is represented by Grimes and Innes bluffs, by the more recent Red River bottoms. In the Red River valley the "upland flats" were made into terrace benches at this time by the trenching of the Port Hudson deposits. To-day these "upland flats" form a notable minor feature of the topography and are particularly well developed in Lafayette County, Ark., and Bossier Parish, La., along what is perhaps the old course of Red River, which after the filling of the valleys, was abandoned for a more westerly course following the smaller valley of Sulphur Fork through eastern Caddo Parish (Pls. XXV, A; XXVII).

In parts of the Mississippi Valley where the erosion has been somewhat irregular these Port Hudson deposits have not been

[78] Hilgard, E. W., On the geological history of the Gulf of Mexico: Proc. Am. Assoc. Adv. Sci., 1871, pp. 230-236; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp. 398-404; 48th Cong., 1st sess., House Ex. Doc. No. 37, vol. 19, 1884, pp. 480-481; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 118, 175-176; Geol. Survey Louisiana, Rept. of 1902, pp, 138-169.

completely worn down to the level of the surrounding gradational plains, and these remnants, though much below the height of the main terraces, are still noteworthy because of their peculiar soil, their relief above the bottoms, and the fact that the banks of the waterways traversing them are lower than the surrounding lands—like true upland creeks—while in the recent flood-plains the banks are typically higher and form more or less pronounced natural levees. To this class belong the Bayou Macon Hills (fig. 23, p, 51, Pl. XXVII,) and the hardly noticeable elevation just above high water extending from the high Bastrop Hills northward toward Dermot, Ark.

On the small tributary streams in the hill-land areas, especially toward the headwaters, the cutting has been less, and the present flood plains of these minor streams are often essentially the



From U. S. Geol. Surv.

A. Drainage in early Quaternary time. *B*. Present drainage.

FIG. 24.—Change in Ouachita River drainage near Harrisonburg, La.

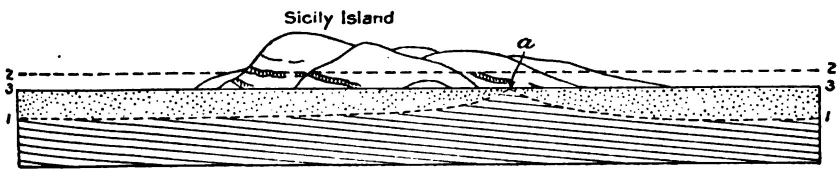
unaltered surface of the old Port Hudson deposits. Along Sabine River, though the Port Hudson deposits form occasional low bluffs and rise slightly above the restricted plain of the present river, they are much more a part of the bottoms, with which they are commonly classed, than are the terraces along the flood-plains of the present Red and Mississippi Rivers, which are commonly regarded as hill lands.

In the erosion of the relatively level Port Hudson constructional valley plains several peculiar topographic features have been produced. Among these are the gorge-like passage of Ouachita River; between Sicily Island Hills and the main

uplands in Catahoula Parish, La.; the transverse cutting of the high terrace remnants by Bayou Bartholomew, Boeuf River and Deer Creek; and the level of the land immediately bordering the Ouachita lower than that bordering the Mississippi at the Arkansas-Louisiana State line (Pls. XXV, XXVII).

DIVERSION OF THE OUACHITA RIVER NEAR HARRISONBURG, LA.

Because of the hardness of the Catahoula formation, a notable contraction has been produced in the Mississippi Valley where these beds cross it (Pls. XXV, B, XXVII); in the period of high level preceding the Port Hudson deposition the group of hills forming the present Sicily Island hill mass was



From U. S. Geol. Surv.

FIG. 25.—Diagram illustrating the deflection of Ouachita River and the cause of the formation of the Catahoula Shoals near Harrisonburg, La.

a. Catahoula Shoals; old divide between north and south flowing drainage.
1-1. Beds of north and south flowing minor streams (First Stage).
2-2. Original level of valley filling (Second Stage).
3-3. Present Ouachita flood plain (Third Stage).

but a promontory on the main Catahoula hill mass and Ouachita River flowed to the east of it (fig. 24 A). When the main valley region was partially filled during the succeeding low-level period, the low divide between the two minor stream valleys, which partially separated this hill mass from the hills to the west, was buried with fluviatile sediments which extended 60 feet above the present bottoms (figs. 23, 25). The Sicily Island hill group was thus entirely separated from the main hill mass by a relatively flat fluviatile plain which was but a portion of the larger constructional plain occupying the whole Mississippi Valley (fig. 25). This plain was doubtless slightly higher in the main valley where the Mississippi brought down large quantities of sediments and the Ouachita naturally occupied the lower ground, and so passed

to the west of the Sicily Island hill mass (fig. 24). In the succeeding period, when the streams cut out a portion of this filling and formed the terraces, the Ouachita cut down and became superimposed on the old rocky divide between the former north and south flowing creeks, and thus formed the present Catahoula Shoals (fig. 25).

TRANSVERSE CHANNELS OF BAYOU BARTHOLOMEW, BOEUF RIVER, AND DEER CREEK

When the slight uplift following the Port Hudson low-level caused the streams to commence trenching the Port Hudson Valley plains, Ouachita River, which then joined the main flood plain at about its present juncture with Saline River in southern Arkansas (Pl. XXV, B), early gained the ascendency over the other streams of the valley. This is evidenced by the courses of the tributary streams—the Bartholomew, the Boeuf, and Deer Creek—which pass through the intervening terrace remnants in more or less pronounced gorges to join it (Pl. XXVII). The cause of this ascendency is, primarily, that the greater amount of sediment carried by the Mississippi tended to produce a relatively greater depression along the present course of the Ouachita, both in building up and cutting out the Port Hudson plain. In the period of low-level the Port Hudson plain was built up more rapidly along the greater silt-carrying Mississippi, while in the succeeding periods of erosion the Ouachita, being less burdened with sediment, more nearly attained a perfect base-level. In the beginning of this period of erosion the streams of the valley, therefore, drained southwest into the Ouachita, and, as the latter has maintained its greater depth, they have continued to do so. In this process the streams have become intrenched in the Port Hudson deposits and, as a result of this and of the irregular removal of the beds by the complex system of drainage in the Mississippi bottoms, a stream sometimes leaves a broad flood plain and deliberately flows through a range of hills to join another flood plain beyond. Thus Bayou Bartholomew follows the eastern edge of a well-marked terrace escarpment 40 to 60 feet

high through Lincoln, Drew, and Ashley counties, Ark., and, though separated from the present flood plain of the Mississippi in this part of its course by a low, almost imperceptible swell, may topographically be regarded as occupying the very western edge of the Mississippi bottoms (Pl. XXVII). In northern Louisiana it turns to the southwest, leaves this broad plain, and passes, in a steep-sided valley but a mile or two wide, through the escarpment which is continued southward in the eastern face of the Bastrop hills.

Similarly, though in by no means so striking a manner, Bayou Boeuf leaves the Mississippi flood plain and passes through a valley between the Bastrop and Bayou Macon Hills to the Ouachita flood plain beyond (Pl. XXVII).

Farther to the south Deer Creek cuts obliquely across the Bayou Macon Hills and separates them from the terraces flanking the Sicily Island hill mass.

DIFFERENCE IN LEVEL BETWEEN THE OUACHITA AND MISSISSIPPI FLOOD PLAINS AT THE LOUISIANA-ARKANSAS STATE LINE.

The difference in the height of the banks of the Mississippi and those of the Ouachita in the latitude of the Arkansas–Louisiana State line is very striking, the top of the former being 112 feet above sea level and that of the latter but 63 feet. The difference is, however, somewhat exaggerated by a small, very recent fault which cuts across the valley near Alabama Landing, La., and which if it continues across the Mississippi flood plain has been completely obliterated by the great amount of sediment carried by that river. The true ratio, with the recent displacement of this fault allowed for, is about 112 to 88—still a striking difference in the elevation of the main stream of the valley and one of its tributaries.

FORMATION OF NATURAL MOUNDS

GENERAL CHARACTER AND THEORIES OF ORIGIN

Some time after the formation of Port Hudson plains a vast number of low mounds, rudely circular, 20 to 100 feet in diameter and 3 to 5 feet high, were formed. These mounds have an extremely wide distribution. They are well developed on the

prairies and pine flats of the Port Hudson deposits along the coast of Louisiana and Texas, where they form the now well-known "pimple prairies," and are popularly associated with the oil deposits, with which, however, they are in no way genetically connected. They occur irregularly throughout the Coastal Plain in northern Louisiana, northeastern Texas, Arkansas, and southeastern Missouri, except in the present flood plains. They are best developed on the Port Hudson terraces, but extend also over the hill lands. They are not restricted to any geologic formation or any range of elevation. The material of which they are composed is commonly a very fine loam, which is reported by the agriculturists to be coarser than, and quite distinct from the surrounding soil, which is commonly clay. Oil-well drillers in southern Louisiana and southeastern Texas report the material in these mounds to be entirely different from the surrounding soil and exactly the same as the fine sand found beneath the 50 to 100 feet of surface clay. The apparent difference in composition is, however, not so great as it seems at first sight and is in part due to the greater elevation and consequent better drainage of the mounds. Careful mechanical analyses will be necessary to determine the true character and degree of this difference.

Mr. J. A. Taff, of the U. S. Survey, reports that similar mounds are very abundant through Indian Territory, where they are best developed on the plains formed during the Tertiary by the erosion of the highly inclined Carboniferous shales and sandstones. They are there, as throughout the Coastal Plain, composed of somewhat coarser materials than that of the surrounding lands, which are commonly flat and water-soaked, while the mounds stand out as somewhat sandy islands. Mr. M. K. Shaler, field assistant, who during the season of 1904 worked with Mr. Taff in Indian Territory, reports that identical mounds occur in southeastern Kansas.

The question of the origin of these mounds is one of the most perplexing problems of this region and can not yet be said to be satisfactorily solved, though the range of possibility has been somewhat narrowed by recent work. The theories which have thus far been advanced may be grouped as follows:

1. Human [79]...... { a. Garden beds. b. Tepee or wigwam sites. c. Burial mounds.

2. Animal [80] ..... { a. Ant hills. b. Mounds of burrowing animals.

3. Water erosion [81] { a. Great currents of floods. b. Slow erosion at low level.

4. Eruptions [82]... { a. Springs or "aqueous" volcanoes due to artesian pressure. b. Gas vents c. Eruptions due to the unequal weight of an uneven clay layer on a water-logged sand bed.

2 Wind [83]........ { a. Low dunes collected by scanty vegetation in a semiarid region of variable winds. b. "roots wads." Masses of earth lifted by the uprooting of trees in storms, which have perhaps been enlarged or modified by burrowing animals.

Of these theories those deserving the most careful attention are (1) the spring and gas-vent theory, (2) the dune theory, and (3) the ant-hill theory.

SPRING AND GAS-VENT THEORY

The spring and gas-vent theory has, until the last year, seemed the most probable of the several hypotheses advanced. The

[79] Nadaillac, Marquis de, Prehistoric America, translated by N. d'Anvers, New York, 1895, p. 182. Lockett, S. H., First Ann. Rept. Topog. Survey, Louisiana, for 1869, 1870, pp. 66-67; Geol. Survey, Louisiana; Rept. for 1899, [1900], p. 194.

[80] Hilgard, E. W., Supplemental and final report of a Geological Reconnoissance of Louisiana, 1873, p. 11.

[81] Owen, D. D , Second Report of a Geological Reconnoissance of part of the state of Arkansas, Philadelphia, 1860, p. 144. Lerch, Otto, A preliminary report on the hills of Louisiana south of the Vicksburg,Shreveport and Pacific Railway; Bull. Louisiana State Exper. Sta., Geology and Agriculture, pt. 2, 1893, p. 106.

[82] Memorial and explorations of the Hon. J. B. Robertson in relation to the agriculture, mineral, and manufacturing resources of the state (Louisiana), with the report of the joint committee: Doc. 2d sess., 2d Legis., Rept. No. 23, 1867; also separate, New Orleans, 1867, pp. 14-15. Hopkins, F. V; First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 80-82. Clendenin, W. W., A preliminary report upon the Florida parishes of east Louisiana and the bluff, prairie, and hill lands of southwest Louisiana; Bull. Louisiana State Exp. Sta , Geology and Agriculture, pt. 3, 1896, pp. 179-183; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 193-194.

[83] Featherman, A., Third Ann. Rept. Botanical Survey of Southwest and Northwest Louisiana, 1871, 1872, pp. 106-107. Clendenin, W. W., op. cit., p. 180.

argument in this case is that throughout the Coastal Plain strata there are large amounts of vegetable matter from which gas has been slowly generating. This gas, with the associated artesian water, on escaping has brought to the surface fine sands and built up low cones. In substantiation of this hypothesis two lines of evidence were adduced. First, there are at widely separated points—namely, near Sulphur City, La., and near Teneha, in northwestern Texas, in regions covered with mounds, a number of low cones a few inches in height and a few feet in diameter in the course of formation (Pl. XXXII). In both cases the very fine sand composing the cones was being brought up by the flow of gas and water in the center of the cone. Second, it is commonly reported by the oil-well drillers in southern Louisiana and southeastern Texas, though the statement could not be satisfactorily verified, that wells sunk on the mounds yield more gas than those in the intermound spaces. In these cases it has been assumed that the gas was of slightly more importance than the artesian water. It is, however, probable that the water was the principal cause and the gas but an accessory. Shepherd[84] has described low spring cones in southeastern Missouri, which are clearly of the same character as those just described. The region in which these occur is likewise covered with natural mounds. A number of cones and irregular "sand sloughs" were produced by water and gas eruptions or by water alone during the New Madrid earthquake of 1811-12, and these have naturally led to the classification of all the mounds in this section as of similar origin. From an examination of some of the mounds in southeastern Missouri along the line of the St. Louis, Iron Mountain and Southern Railway, the writer is inclined to doubt this generalization and to regard the greater number of them as identical with the same phenomena to the south and west, and not of the same origin as the low spring cones or the eruptions of the New Madrid earthquake. This locality is, however, the best argument for a water and gas origin. On Long Island, New York, there are a number of low mud cones which, while not entirely identical with the

[84] Shepherd, E. M., The New Madrid earthquake, Jour. Geol., vol. 13, 1905, pp. 45-62.

From U. S. Geo. Surv.

A

B

SMALL SAND CONES FORMING OVER GAS AND WATER VENT ON FLAT CREEK—THREE MILES SOUTH OF TENEHA, SHELBY COUNTY, TEX.

From U. S. Geol. Surv.

MUD CONES NEAR DOUGLASTOWN, LONG ISLAND, N. Y.
Formed by pressure of underlying artesian water.

mounds, are of interest as examples of cones produced by artesian pressure (Pl. XXXIII).

DUNE THEORY

A wind origin was suggested for these southern mounds by Featherman in 1872[85] and by Clendenin in 1896.[86] Recently Dr. C. W. Hayes, after having examined the mounds in southeastern Texas, observed very similar low mounds clearly due to wind action 15 or 20 miles southwest of Green River City, in southwestern Wyoming, and concluded that the Coastal Plain mounds were of the same origin. The objection to this theory, which is regarded as more probable than that just discussed, is the very great irregularity of wind-made features and the fact that these natural mounds of the south-central United States, over an area at least 300 miles wide and 500 miles long, are notably uniform in size and exactly resemble one another. It would seem that in so large an area a wind origin would involve a greater variation in size than has been observed and would necessitate the presence of occasional dunes or lines of dunes of noteworthy size whose origin could not in any way be doubted. This hypothesis, moreover, requires an arid or semiarid climate in this region at a very recent time, of which there is no other evidence and which, in the present state of the investigation, can hardly be considered as conclusively proved.

ANT-HILL THEORY

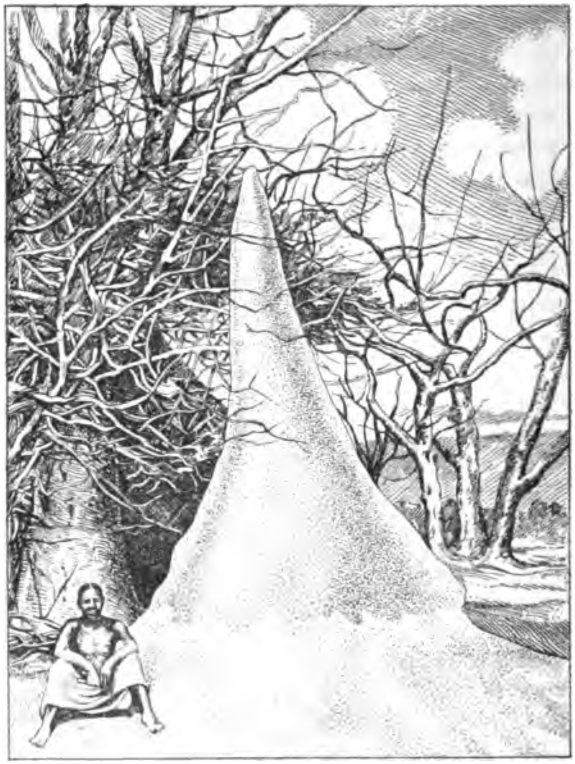
In considering the ant-hill hypothesis it must be conceded at the outset that in size and distribution these mounds exceed the work of any mound-building insects in this country. They are, however, approximated in size by some of the mounds of the leaf-cutting ants, the Atta. These are reported by Dr. W. M. Wheeler, formerly professor of zoölogy in the State University of Texas and an authority on ants, to reach a diameter in Texas of 40 to 50 feet and a height of 1 to 2 feet. He states that the hills are very stable and persist after the colony has migrated

[85] Third Ann. Rept. Botanical Survey of Southwest and Northwest Louisiana, 1871, 1872, pp. 106-107.

[86] Preliminary report upon the Florida parishes of east Louisiana and the bluff, prairie, and hill lands of southwest Louisiana; Bull. La. State Exp. Sta., Geology and Agriculture, pt. 3, 1896, p. 180.

or become extinct. Mr. E. A. Schwarz, of the National Museum, reports that in Cuba the Atta hills often reach a height of 10 to 12 feet, with a diameter several times as great, and in places completely overrun the cane fields. These occurrences greatly re-enforce the theory of an ant origin.

An alternative "ant theory" is that these mounds are the work



From U. S. Geol. Surv.

FIG 26.—An African termite hill. (Drawing from photograph by Sir H. H. Johnston.[88]) Note the broad, low mound, on which the central spire rests, produced by wash of the central hill.

of mound-building varieties of the so-called "white ants" (termites), which are notably developed in the tropical parts of South America and Africa and in Australia.[87] The immense hills

[87] For a discussion of termites see Encylcopædia Brittannica, 10th ed., vol. 33, 1902, pp. 255–256, and the references there given.

From U. S. Geol. Surv. Photographed by G. K. Gilbert.

LOW CIRCULAR DUNES IN WHITE VALLEY, WESTERN UTAH.

Produced by sand or dust lodging about low desert vegetation.

of certain varieties of these termites, notably *Termes bellicosus*, which forms a very important minor topographic feature over wide areas in Africa, are the nearest approach of any insect work to these natural mounds, both in size and bulk of material represented. These structures have a conical, sugar-loaf, or bee-hive shape and range from 6 to 20 feet in height and 50 or more feet in diameter (fig. 26). They are composed of mud in which more or less vegetable matter is mixed, and so, like the mounds, are best developed in clay regions. Should these cones be deserted by the termites, they would weather down into broad, low mounds which because of their greater height and of the vegetable matter mixed with them, would have a looser character than the surrounding soil.

Regarded as the work of termites, these mounds suggest a warmer and moister climate, though modifications such as those which enabled large elephants, camels, and animals of the sloth and armadillo families to live in this region would also have enabled these now similarly restricted mound-building termites to do the same, and the causes which resulted in the extinction of the larger animals would in like manner, though at a later date, have destroyed the termites.

Opposed to the termite theory and pointing to a rodent origin is the fact that in exceptional cases in southern Arkansas these mounds are covered with gravel. This is more probably due to subsequent work of burrowing animals.

In conclusion it may be said that these mounds are clearly due to causes not now in operation in this region, and no theory of origin yet suggested is entirely satisfactory. The dune and ant-hill theories are, perhaps, the best supported. On either of these hypotheses the mounds are indications of important climatic changes in recent time, and so offer a line of investigation which may develop very important and far-reaching results.[89]

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[88] British Central Africa, New York, 1897, p. 371.

[89] Since the above was written the following short articles, discussing the general subject of natural mounds, have appeared in Science: Branner, John C., Science, n. s., vol. 21, 1905, pp. 514–515; Hilgard, E. W., id., pp. 551–552; Spillman, W. J., id., p. 632; Purdue, A. H., id., pp. 823–824; and Piper, C. V., id., pp. 824–825. Branner and Purdue suggest that these mounds may represent immense concretionary formations. Spillman refers certain

RECENT

In Recent time, which may be defined more or less arbitrarily as that since the extinction of the mastodon and associated animals, and in this region more particularly as that since the completion of the main erosion of the Port Hudson deposits in the larger valleys, the topographic and geologic changes have been very slight. With the exception of irregular benches on the hillsides produced by landslips which, as their formation began in early Quaternary time, are only in part Recent, the effects of these changes are noteworthy only in the bottoms. Aside from such local results as the destruction of river banks, the building of bars, and the formation of cut-offs, all produced by the wandering of the principal rivers in their flood plains and the building up of the front lands above the back lands by the deposition of sediment in overflows, the most important of these changes are (1) the formation and destruction of the lakes of Red River Valley, (2) the deflection of Red River through a narrow gap in the terrace deposits near Marksville, (3) the production of the "Rapides" near Alexandria, (4) the development of small rapids on Sabine and Angelina rivers and the production of a low swampy area in the latter above the rapids, and (5) a slight movement along the Red River fault line near Alabama Landing, La., with the resultant extreme swamping of the bottoms from that point to above the mouth of Bayou Moro, in Arkansas.

Of these, the formation and destruction of the lakes of Red River Valley is by far the most important, and, happening, as it has, in historic and semi-historic times, is of peculiar interest as an example of geology in the making.

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mounds in southwest Missouri to unequal weathering of limestone containing large chert masses. Branner gives many references to the mounds of the Pacific coast, for which he states the following theories have been advanced: (1) surface erosion, (2) glacial origin, (3) æolian origin, (4) human origin, (5) burrowing animals, including ants and (6) fish nests exposed by elevation. Bushnell, D. I., jr., Science, n. s., vol. 22, 1905, pp. 712–714, has suggested the human origin theory, and this phase of the matter has been discussed by the writer in Science., n s., vol. 23, 1905, pp. 34–36.

STRUCTURE

BROADER STRUCTURAL FEATURES RESULTING FROM CAUSES ASSOCIATED WITH CONDITIONS OF DEPOSITION

Earlier chapters in historical geology indicate that the Jurassic land surface was peneplained in this region, and very gradually warped in two principal directions. It was gently tilted southward in the direction of the present Gulf coast, and later, while the gulfward tilting was still continuing, a broad trough was developed southwest along the axis of the present Mississippi Valley, which, indeed, owes its origin to this fold. The general effect of this tilting was to give to all the beds deposited by the ocean on this old land surface a very gentle slope toward the Gulf, and, after a time, toward the Mississippi Valley. The relative intensity of these two slopes depended on the location; near the Mississippi Valley the slope toward the trough was more important, while to the east and west the gulfward slope increased in value until it became the principal element. The effect of this very slow progressive tilting and the usual wedge or lens shape of marine deposits, which are thin toward the land and thicker seaward, was to give to the lowest beds a greater slope than the succeeding ones.[90] (Pls. XXVII, XXXVIII, secs. B, D, E, F, G, H, I).

Thus the older Cretaceous beds—the Trinity, Goodland (Fredericksburg), and Washita formations—which attain great thickness in central Texas, grow thinner in passing eastward along the outcrop, and finally disappear in southwestern Arkansas. (See Pl. XXVII, compare secs. F, D, E, B, Pl. XXXVIII). The lowest formation of the upper Cretaceous in Arkansas, the Bingen, likewise thins out rapidly to the east, while to the west it grades into a very thick series, which ultimately becomes two or three distinct formations (compare secs. E, D, H, Pl. XXXVIII). In the latter part of the Cretaceous, with the development of the Mississippi embayment, the deep water shifted eastward, and the clays of this period, which are dark and cal-

[90] Still farther seaward the beds again grow thinner, but no such thinning has been observed in this area, and it is presumed that the point where these beds thin out is beyond the area under discussion.

careous in Texas, contain, in the Arkansas and Mississippi regions, large amounts of chalk and chalk marls.

In the Tertiary strata somewhat similiar causes have resulted in the entire absence of the Vicksburg beds west of Catahoula Parish, La. (Pl. XXVII.)

Besides these variations in thickness and lithological characters, due to conditions intimately connected with deposition, and the initial dips due to the gentle tilting of the surface of the old Triassic peneplain, notable variations in the structure have been produced in several other ways; (1) by the domes, (2) by the Angelina-Caldwell flexure, (3) by the Red River-Alabama Landing fault.

CHANGES BY SUBSEQUENT OROGRAPHIC MOVEMENTS

DOMES

The domes, twelve of which are now known in northern Louisiana and eastern Texas (Pl. XXXVIII), the presence of a thirteenth being suspected, are by far the most unique structural feature in this region. They are very symmetrical, four-sided folds or quaquaversals of Cretaceous strata, about a mile in diameter, that represent deformations of from 1,000 to 4,000 feet. They penetrate the Eocene beds without materially disturbing them, except, perhaps the Midway, and though their major development and partial truncation by erosion occurred during the late Cretaceous and early Tertiary, the Winnfield dome is known to have moved in post-Claiborne time, and the Belle Isle, one of a series of closely related domes in southern Louisiana, shows movements in Quaternary time.[91] In point of origin it is thought that these domes were perhaps produced by the upward pressure of intrusions of igneous rocks of limited area (see p. 18), and so may be termed bysmalithic[92] domes or bysmalithic quaquaversals.[93]

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[91] Geol. Survey Louisiana, Rept. for 1899, 1900, pp. 228-229; Geol. Survey Louisiana, Rept. of 1902, pp, 99-100.

[92] Iddings, Jour. Geol., vol. 6, 1898 pp.705-706.

[93] Since the above was written I have found that Lee Hager (Eng. and Min. Jour., vol. 78, 1904, pp. 137-139, 180-183) has suggested a hypothesis which explains the origin of these and very similar domes in southern Louisiana and southeastern Texas by the upthrust of an igneous plug. His

From U. S. Geol. Surv.

GOOWIN RAPIDS ON SABINE RIVER, NEAR COLUMBUS, LA.

One of the group of low shoals produced by recent upward movement along the Angelina-Caldwell flexure.

ANGELINA-CALDWELL FLEXURE

The low Angelina-Caldwell monoclinal flexure is known to extend from Angelina County, Tex., through Louisiana north of Natchitoches, Winnfield, and Columbia to Mississippi River north of Vicksburg (Pls. XXXVII; XXXVIII, secs. A, B, C, D, F). It began to develop in Tertiary time, perhaps as early as the Oligocene, and is still a line of weakness. Recent movement along its west end has resulted in the formation of a series of shoals on Sabine River and in the swamping of a part of the Angelina River Valley in Angelina and Nacogdoches counties, Tex. It has almost entirely destroyed the southern element of the dip of the beds between its northern edge and a point about 60 miles south of the Paleozoic border. Along the line of the flexure the dip of the Claiborne beds ranges from 46 feet at Vicksburg to 150 feet on Sabine River. Still farther south the dip becomes less, though this change of the dip has as yet been actually observed only on Sabine River, where, between Hattens Ferry and Burrs Ferry, it changes from 150 feet to about 30 feet per mile (Pl. XXVII).

It should be noted that the Nacogdoches oil field occurs near the upper bend of this monocline, and that the oil springs reported in Sabine Parish, La., occur in the same relation to this fold.

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theory is in the most essential particulars parallel to the one here advanced. The fact that two workers in this field have independently arrived at the same hypothesis as the only one at all in accordance with the known facts greatly adds to its probable value. Mr. Hager's suggestion that the wonderful salt, sulphur, aud gypsum deposits of this southern region are not of normal marine origin, but were concentrated and redeposited by the heated waters circulating around these igneous intrusions, and that these deposits are to be regarded as essentially the product of the change in conditions produced by these intrusions, appeals to me as the most probable theory that has yet been advanced. The stratigraphic and structural relations of the salt deposits of Grand Saline, Tex., are not well known, but the beds here do not indicate a dome, and the salt beds have therefore been referred to ordinary salt-pan action. The brines of the various northern Louisiana salines are in part clearly derived from water-bearing Cretaceous beds which have been brought up by this extreme folding, but the brines may be in part derived from salt beds formed about the center cf the uplift and as yet unexposed.

RED RIVER-ALABAMA LANDING FAULT

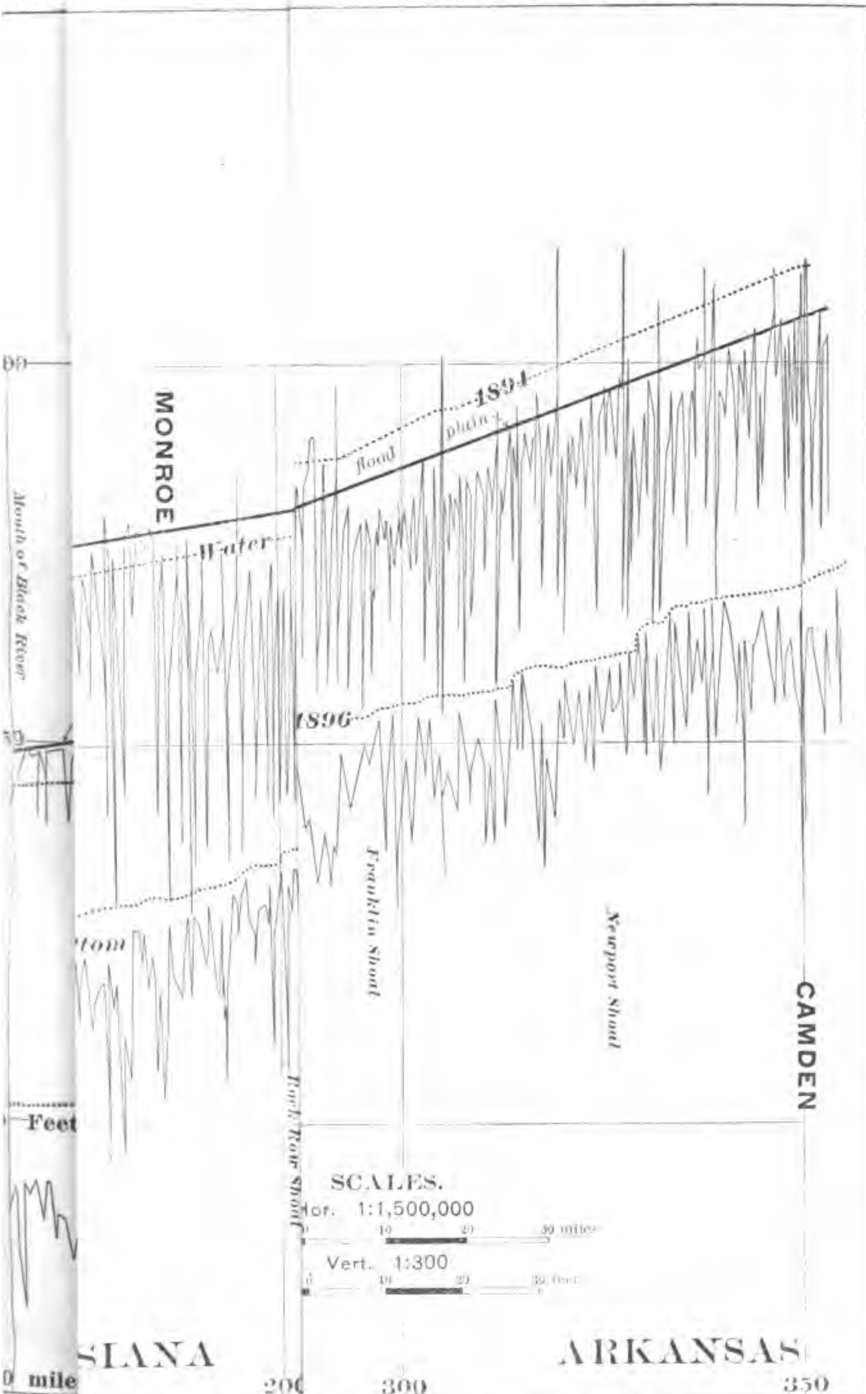
The Red River-Alabama Landing fault extends across northern Louisiana and southern Arkansas into northeastern Texas, approximately in the position shown on Pl. XXXVII, though in a much more irregular manner. Like the Angelina-Caldwell flexure, it is of late Tertiary age and has been the site of movement in the present time. The total displacement or "throw" of this fault along the Little Rock-Marksville section (Pl. XXXVIII, sec. B), where the data regarding it are most complete, is in the neighborhood of 600 feet, with the downthrow to the north.

The throw of the Red River fault, of which this seems to be the continuation, is given by Hill as about 626 feet at Preston and 617 feet north of Denison, Tex. The close agreement of these figures is very surprising when the distance between the places of measurement—about 275 miles—is considered, as such uniformity of fault structure is unusual.

Evidence of recent movement along this line is found on the Ouachita River just above Alabama Landing, where the displacement revealed by the careful levels of the United States engineers is 25 feet (Pl. XXXVI). This movement, which is so recent that the river has not yet perceptibly filled the depression, has resulted in the production of an extremely low, swampy area extending almost to the mouth of Smackover Creek in Arkansas.

LOCAL STRUCTURAL FEATURES

Besides these broader structural features, there are in every locality many minor examples of faults and folds on a minute scale that have no bearing on the general structure of the region, but are of importance to the teacher and student as examples of the larger and much more obscure occurrences. These little structural phenomena are generally the result of the readjustment of the strata resulting from erosion, and in some cases to slight readjustments produced by earthquakes.



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nel and right bank of ., by the U. S. Engineers."

DIP OF STRATA

The direction and character of the dip of the strata is shown on the structural (Pl. XXVII) and hydrologic sections (Pl. XXXVIII) and may be inferred from the figures given on the underground-water maps (Pls. XL–XLIII). However, the following values may be of interest:

The slope of the old Triassic land surface, or the "bed rock," is from 100 to 125 feet per mile all along the Cretaceous-Paleozoic contact in southern Arkansas from Arkadelphia westward. Northeast of Arkadelphia nothing is definitely known regarding its slope, and there is some indication that it may be faulted.

The dip of the upper part of the Bingen formation (the sub-Clarksville sand) is 70 feet per mile about Gurdon and 80 feet per mile at Texarkana.

The Nacatoch sands have a dip of 56 feet at Gurdon, 65 feet at Hope, 80 feet at Fulton, and 73 feet at Texarkana.

The southward element of the dip of the base of the Jackson north of the Red River-Alabama Landing fault along the line of the sections from Vicksburg to Marked Tree (Memphis) (Pl. XXXVIII, sec. A), and from Monroe to Little Rock (Pl. XXXVIII, sec. B) is about 1.7 feet per mile.

The southward element of the dip of the base of the Claiborne along the Angelina-Caldwell flexure is 46 feet per mile at Vicksburg, 48 feet at Columbia, 50 feet at Colfax, and 150 feet on Sabine River.

The dips toward the Mississippi trough range from 8 to 16 feet per mile.

CHAPTER II

GENERAL UNDERGROUND WATER CONDITIONS

INTRODUCTION

SOURCE OF UNDERGROUND WATER

Of the 40 to 50 inches of rain which commonly fall during each year in northern Louisiana and southern Arkansas (fig. 27) a considerable portion immediately flows off the surface in streams and ultimately reaches the sea. Another portion passes into the ground and, after a longer or shorter journey, returns to the surface in the form of springs either on the land or under bodies of water. In both of these cases a part is lost by evaporation, and a certain amount, though a comparatively small percentage, is consumed by living organisms and in chemical work.

The portion which passes into the earth furnishes the entire supply of well water both in surface and deep wells. Its availability for this purpose at any point and the permanency and quality of the supply, as well as the height to which the water will rise above the bed in which it is encountered, depend on the relative position, elevation, and permeability of the different strata in that region. Its potability, or mineral character, depends on the soluble minerals contained in the beds through which it passes.

The percentage of the rainfall which sinks into the earth is determined by (1) the character of the rains, whether of a slow and steady or a torrential nature; (2) the topography of the country, whether flat or with many steep slopes; (3) the character of the vegetation covering the surface; and (4) the porosity of the soil and the physical character and state of saturation of the underlying beds.

NATURE OF MOVEMENT OF UNDERGROUND WATER

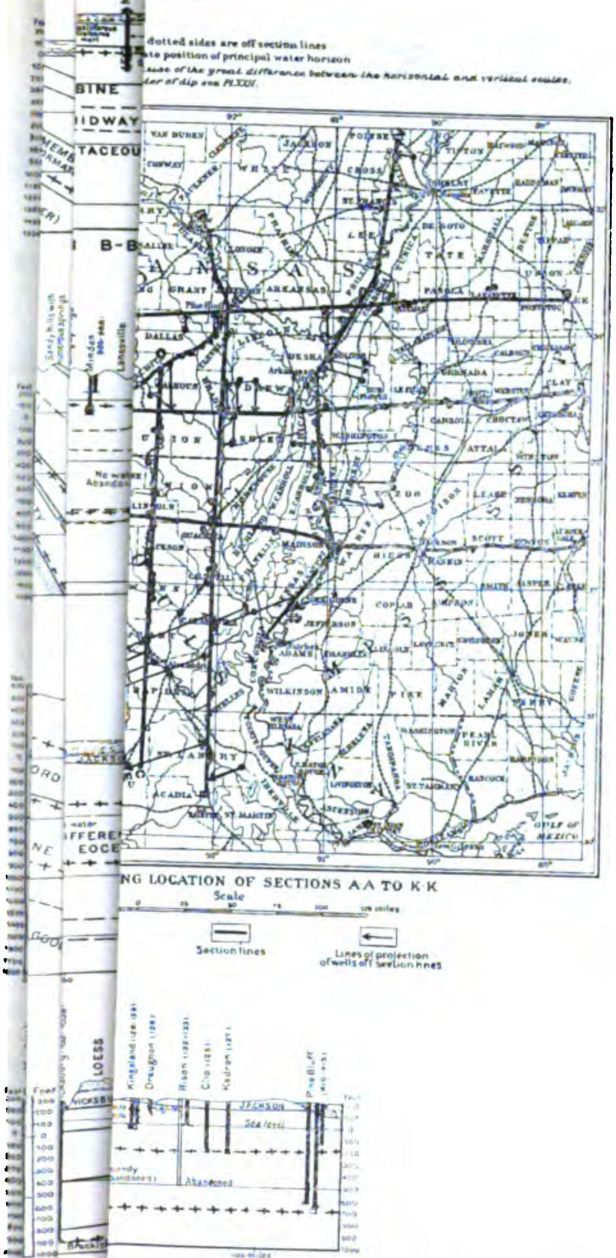
Except in thick limestone beds containing caverns, underground waters very rarely travel through channels or conduits of appreciable size, or in any way resemble surface streams; and

...XPLANATION

...which well is discussed in Chapter V
...wing well
...ch water rises in non flowing wells

...ing sands

...dotted sides are off section lines
...te position of principal water horizon
...ause of the great difference between the horizontal and vertical scales
...ter of dip see Pl. XXXI.

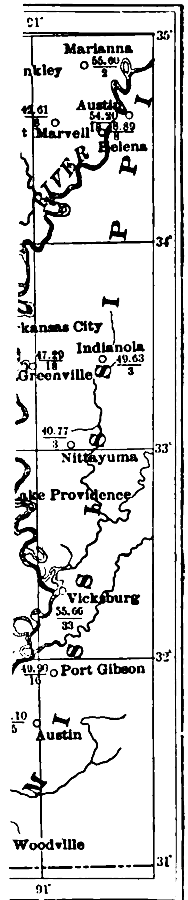


...NG LOCATION OF SECTIONS A-A TO K-K

Scale

Section lines

Lines of projection of wells off section lines



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By A. C. Veatch.

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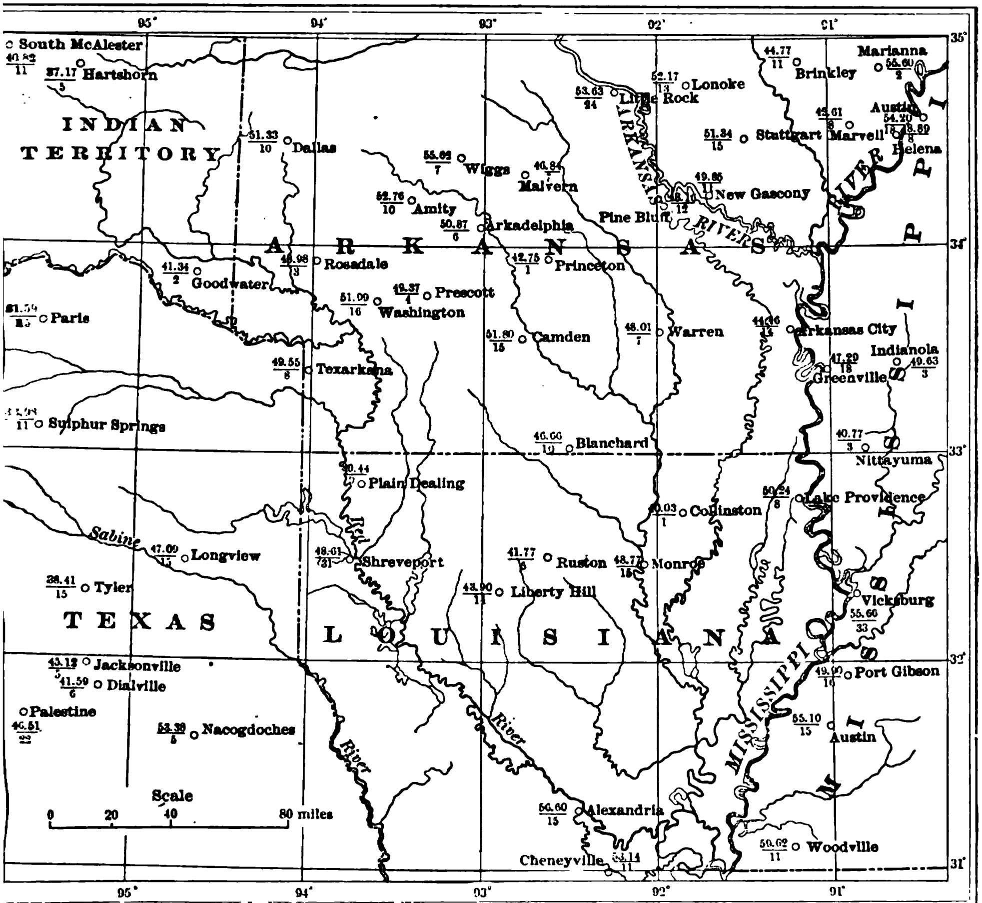


U. S. Geol. Surv.

27.—**Annual rainfall in northern Louisiana and southern Arkansas compiled from reports of the United States Weather Bureau for the years 1902 and 1903. Lower figures represent period of years; upper figures, average rainfall for period given.**

seldom can the underground water system of any area be said to even remotely "resemble the veins of the human body." The true cavern streams furnish an extremely small percentage of the world's water supply derived from wells, and well waters on the whole are to be regarded as coming from the saturated portions of porous beds, through which the water moves in the small spaces between the particles as the sand of a sand bed or sandstone, or the gravel of a gravel bed or conglomerate. This motion is to be described as a slow seeping, in which the water moves at the rate of a few feet per day, rather than a few miles, as in surface streams.

The manner and character of this flow may be artificially and somewhat arbitrarily shown by taking a sand pile of considerable size, placed on a relatively hard or impervious material, and spraying its center with water. When the lower portion of the pile has become saturated, little streams will begin to trickle from one or more points at the base, the number depending on the shape of the ground where the pile is situated. These little rivulets represent springs and it will be found that the water will flow for some time after the cessation of the spraying, the length of time depending on the size of the pile and the coarseness of the particles composing it. Imagine this sand pile increased to many feet in thickness and covering the top of a hill or group of hills which is underlain by clay beds, and you have an idea of the character and cause of many of the springs in northern Louisiana and southern Arkansas.[1]

ZONES OF SATURATION

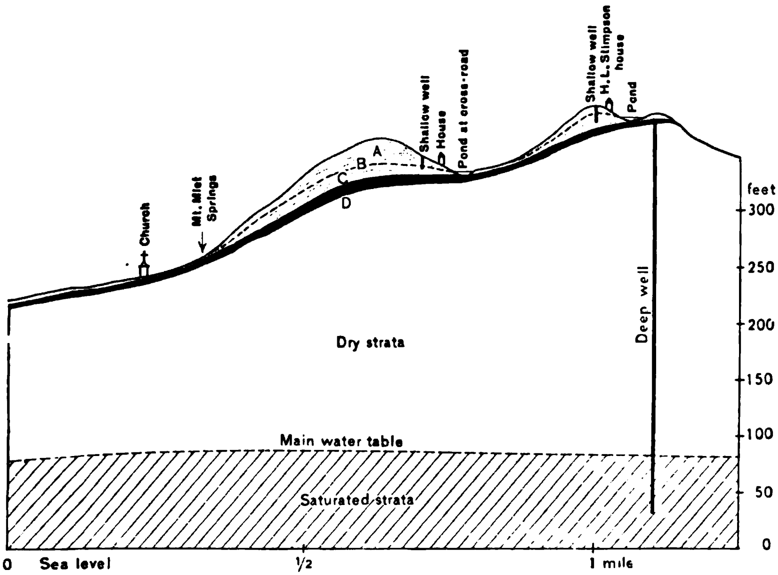
The effect of this constant influx of water into the earth is to completely saturate the rocks between an upper limit, whose position depends largely on the amount of rainfall and the relief of the country, and a lower limit, fixed by the point below which the enormous pressure of the upper layers of rocks prevents the existence of spaces of any character between the rock particles. The position of this zone of no pores has been estimated by Van Hise[2] to be about 6 miles from the surface.

[1] For another type of springs see U.S.Geol.Survey; Prof. Pap., No. 46, p. 76.

[2] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 593.

MAIN GROUND-WATER TABLE.

The upper limit of this zone of complete saturation is known as the main ground-water table. In regions of heavy rainfall it is relatively near the surface, while in areas of light precipitation it is deep in the ground. The possibility of obtaining water below this main ground-water table depends on the location of the coarse beds, such as sand and gravel, which will yield their contained water readily. Clay beds in this zone, though also completely saturated, release the water extremely slowly if at all, and have, therefore, no water-bearing value.



From U. S. Geol. Surv.

FIG. 28.—Cross section on Long Island, New York, showing the relation of a perched water table to the main water table and the production of springs dependent on a perched water table.

PERCHED GROUND-WATER TABLES

Above this zone of complete saturation and separated from it by nonsaturated strata, there are, in regions containing irregular clay or relatively impervious beds, more or less elevated, limited, and disconnected zones of saturation which may be termed "perched water tables." They supply local shallow wells, and when cut by valleys produce springs of greater or less import-

ance (fig. 28). Wells dependent on perched water tables are in general much less satisfactory than those which pass below the main water table, as they derive their supply from more or less limited bodies of saturated strata which are quickly affected by periods of drought.

VARIATIONS OF PRESSURE OR HEAD

The water pressures in the main zone of saturation are very unequal. The differences in the coarseness of the strata, the leakage through springs, and the constant additions from rainfall prevent their ready equalization. They vary greatly in different layers in the same region, and in the same layer in different

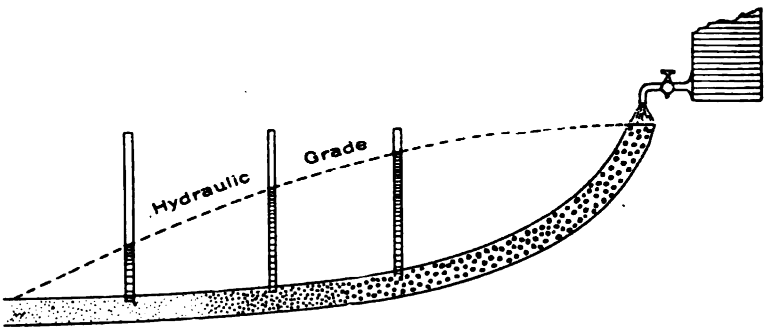
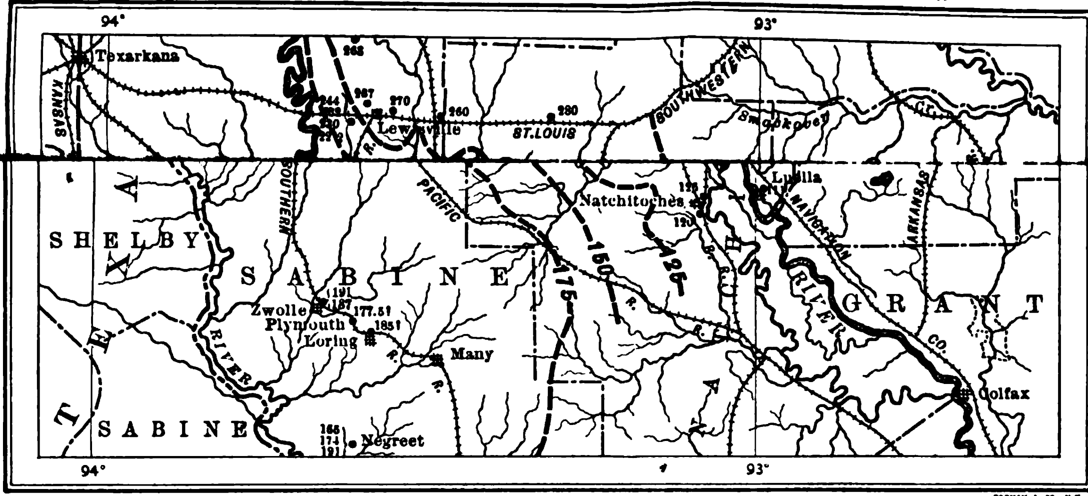


FIG. 29.—Experimental illustration of loss of head by resistance and leakage. (After David, 1893.)

regions. The extent and cause of this variation is indicated by the character of the factors in the following equation:

Pressure head at a given point in any stratum, expressed in feet above sea level=elevation of ground-water table at source—loss by resistance—loss by leakage.

All the members on the right-hand side of this equation are irregular variables. The first, the elevation of the ground-water table at the outcrop or source, depends on the elevation of the surface, which changes at different points. The second depends on the size of the spaces between the grains, which in even the most uniform beds is a constantly changing quantity and in beds such as those of the Lower Eocene is extremely variable. The third varies with any change in the



Scale
0 10 20 30 miles

•191 Elevation to which water will rise, in feet above sea level.

200 Approximate lines of equal head.

From U. S. Geol. Surv.

By A. C. Veatch, 1903.

Map showing variation in head of water in the Sabine Sands in Northwestern Louisiana and Southwestern Arkansas.

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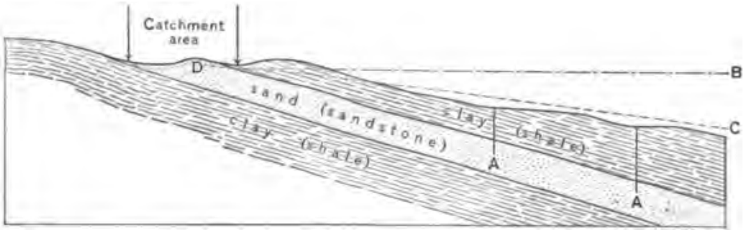
coarseness of the adjacent beds, which are never constant, and is affected by faults, joints, and other natural breaks.

This variation may be artificially shown in the manner indicated in fig. 29. In this experiment a tube is filled with sand, coarse shot, and marbles, representing beds of different coarseness, and the lower end of the tube is closed with a brick to prevent the materials from running out. When water is allowed to flow in from above, it rises to different heights in the small tubes, representing wells.



From U. S. Geol. Surv.

FIG. 30.—Diagram showing the common arrangement of factors producing artesian wells *A*, Artesian wells; *B*, head of water if there were no loss by resistance or leakage; *C*, actual head of hydraulic gradient; *D*, ground-water table at outcrop.

CAUSES PRODUCING ARTESIAN OR FLOWING WELLS

It is these variations in the pressure or head that make flowing or artesian wells possible under certain conditions. These may be briefly stated as follows:

1. There should be relatively porous beds suitably situated to collect and transmit the water.
2. There should be less porous or relatively impervious layers so placed that they may confine the water collected.
3. The level of the ground-water table at the source should be enough higher than the surface at the point where the well is drilled to compensate for the loss of head due to resistance and leakage.

In order that the well may be permanently artesian it is also necessary that there be sufficient rainfall and that the demand be not greater than the rate at which the water can flow through the porous stratum or strata.

The arrangement of the factors which produce a flow is by no means constant. They vary considerably from point to point and relatively new combinations are to be continually expected. Possibly the most usual combination is that shown in the accompanying diagram (fig. 30). Here the confining beds are clay

and the porous bed is a sand which dips regularly in the direction in which the surface slopes. Water falling in the region marked "catchment area" sinks into the sand and supplies the artesian wells drilled on lower ground. Most of the artesian wells of this region have this arrangement of factors, which may be taken as typical of a large class of artesian wells, being perhaps, the one most commonly expounded and understood, but a radical rearrangement of factors will produce results depending on the same general principles.[3]

PRINCIPAL WATER-BEARING HORIZONS

The water-bearing value of the geologic formations of northern Louisiana and their relations to one another are briefly outlined in the table opposite and graphically shown on Pl. XXXVIII.

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[3] For such exceptions, other than those described on pp. 81–82, see Prof. Paper U. S. Geol. Survey No. 44, 1906, pp. 68–72.

Water-bearing value of geologic formations of northern Louisiana.[4]

Geologic subdivisions.				Character of deposits.	Water-bearing value.
Quaternary.	Recent.	Alluvium.		Veneer of sand, silt, and clay on flood-plains.	Seldom of value except in connection with the underlying Port Hudson deposits.
Quaternary.	Pleistocene.	Port Hudson formation.		Clays and silts underlain by gravel beds, which occur beneath all the river valleys and as terraces along their sides.	The sand and gravel beds of this formation beneath the river valleys, and generally beneath the terraces, yield inexhaustible supplies of water, often hard and alkaline.
Tertiary.	Pliocene.	Lafayette formation.		Silt, sand, and gravel, forming a very irregular mantle over the older beds.	Of very little value, except in extreme southern portion of this region. Supplies occasional shallow wells, though these generally depend on the older formations.
Tertiary.	Oligocene.	Fleming clay.		Green calcareous clay.	None. Shallow wells in the area of the outcrop of this formation depend entirely on covering of surficial sand and gravel (Lafayette).
Tertiary.	Oligocene.	Catahoula formation.		Green clays, with layer of white sand and sandstone.	Contains several important horizons in central Louisiana. (See Pl. XXXVIII.)
Tertiary.	Oligocene.	Vicksburg formation.		Limestones and calcareous clays, somewhat lignitiferous.	None.
Tertiary.	Eocene.	Jackson formation.		Highly fossiliferous calcareous clays.	Serves in central Louisiana to retain water in underlying beds.
Tertiary.	Eocene.	Claiborne formation.	Cockfield member.	Lignitiferous sands and clays.	One of the two important water-bearing formations of the Eocene. Water-bearing sands irregularly throughout, with the coarser and more prolific beds at the base.
Tertiary.	Eocene.	Claiborne formation.		Calcareous clays, changing to the north into lignitiferous sands and clays.	Where typically developed, in central Louisiana, has small water-bearing value; to the north it contains several minor water-bearing horizons.[5]
Tertiary.	Eocene.	Sabine formation.		Lignitiferous sands and clays.	The most important water-bearing formation of the Eocene in this section; contains several horizons.
Tertiary.	Eocene.	Midway formation.		Limestones and marly clays.	None.

[4] See table of geologic history, pp. 14 and 15.

[5] The water-bearing sands reported in this formation in Alabama and eastern Mississippi seem to be represented in this region in the water-bearing beds of the basal portion of the Cockfield, which is a part of the Claiborne.

EOCENE HORIZONS

SABINE WATER SANDS

The main Sabine water horizons, as developed in northern Louisiana (Pl. XXXVIII, secs. B, C, D, E, F), occur from 100 to 200 feet below the lower Claiborne. To the south, where the formation thickens considerably, the water-bearing sands increase in number and are fairly uniformly distributed throughout the Sabine (Pl. XXXVIII, secs. E, F). In Arkansas a group of horizons is found in the Sabine at New Lewisville and Stamps, though only the upper ones, near the Claiborne, are generally developed. This horizon continues in the Mississippi Valley, where it has been successfully developed in many wells.

Pressure.—The pressure in the Sabine sands in the area in which this formation outcrops, and where it is covered by but a thin layer of the Claiborne formation, varies almost directly with the local topography or the local position of the main ground-water table. Here artesian wells are of local and more or less accidental occurrence. To the south and east, where these sands become embedded beneath the more impervious beds of the lower Claiborne, artesian conditions are developed which are uniform over considerable areas (Pl. XL). Along the Mississippi flood-plain the head is greater on the east than on the west, as the hill land in northern Mississippi is uniformly higher than that in Arkansas and northern Louisiana, which is deeply trenched by Ouachita and Red Rivers.

Quality.—Water from the Sabine horizons is commonly soft and somewhat alkaline. Like some of the Cretaceous waters, it tends to collect soluble salts and is more highly mineral in deep than in shallow wells. In Sabine Parish (966, 969) the deep waters are somewhat mineral. At Natchitoches (909, 911) and Lueila (906) they are so highly charged with salt that they can not be used. This is due perhaps to brine which has leaked from the Cretaceous domes to the north. The area in which the water in the Sabine sands has been rendered impotable in this way has not been determined, but it probably includes southwest Bienville, eastern Red River, Natchitoches, with the possible exception of the west central portion, southern Winn, and central and western Grant parishes. At Monroe the water is so mineral that

LOUISIANA

CHARACTER OF WATER
A = Alkaline B = Brine S = Soft I = Iron X = Sulphurous

C* - C...ALL FIGURES show total depth of wells or depth

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it is only occasionally used in the city water-works, though extensively employed for industrial purposes. At Delhi and Vicksburg the water, though artesian, is very alkaline, and this condition probably affects a large part of the Mississippi Valley in Louisiana east of Ouachita River. Brine has been obtained in this horizon at Crossett, Ark. (well 6, Pl. XXXVIII, sec. B), but all other developments in Arkansas and northwestern Mississippi, as at Wilmer and Pine Bluff, Ark. (410–415), and Indianola, Ittabena (1022), Greenwood (1018, 1020, 1021), O'Reilly (1005), Cleveland (1003–1004), Tchula (1012–1015) and Yazoo City, Miss. (1048), have yielded potable water.

Availability.—In the area which is underlain by the Sabine and the corresponding undifferentiated Eocene horizons (Pl. XL) these water-bearing sands may, in general, be said to be available at any point. Wells at Waldo (141) and near Bearden (628), while both developing water at the proper depths, are regarded as failures, the first because the supply did not seem sufficient and the second because the sand was so very fine that it easily passed through the strainers. The water was, moreover, very alkaline. It is felt, however, because of the great irregularity of the Eocene beds that these occurrences are essentially local and do not prove that a good well could not be developed at the same horizon 10 or 20 miles away. The only factor greatly restricting the development of these horizons is that imposed by the quality of the water in the areas near the domes.

WATER-BEARING VALUE OF CLAIBORNE (LOWER) FORMATION

In central Louisiana the fossiliferous Claiborne is a calcareous clay having no water-bearing value. To the north, however, it merges into lignitiferous sands and clays, and occasionally water-bearing strata are developed, as at Ruston and Arcadia, La. (Pl XXXVIII, sec. I). Along Mississippi River in Arkansas and Mississippi occasional horizons are developed in the undifferentiated Eocene in beds which are the stratigraphic equivalents of this part of the Claiborne (Pl. XXXVIII, secs. A, H), but the more important and persistent horizons are in the overlying Cockfield, which is of Claiborne age, though separated in central Louisiana because of lithologic differences.

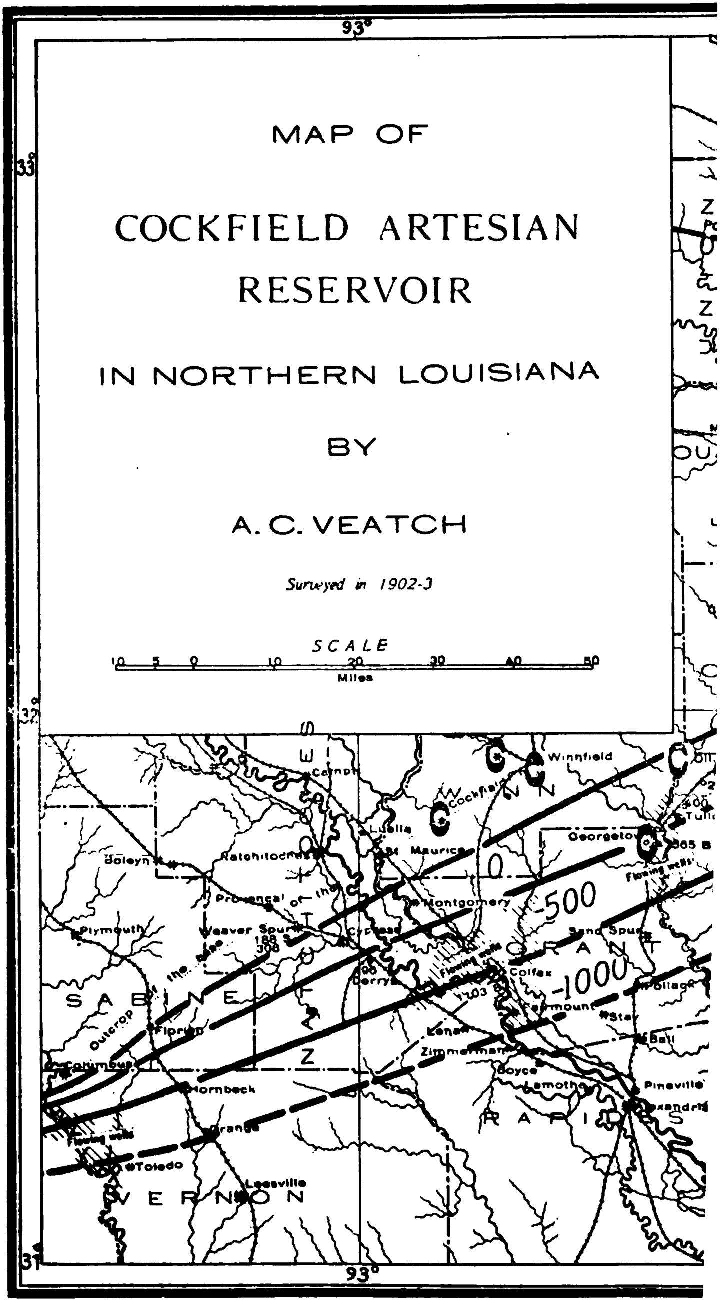
In the regions marked fossiliferous Claiborne on the geologic map (Pl. XXVII) it will generally be advisable to continue wells to the Sabine water sands.

COCKFIELD WATER SANDS

In central Louisiana the basal layers of the Cockfield member of the Claiborne are sandy, and where penetrated, except at Delhi, La., and Vicksburg, Miss., have yielded water (Pl. XLI). As a rule, the water in the deeper wells, as at Leland (855), Rochelle (881), Olla (856–857), Tullos (861), and Colfax (877), is impotable, though an exception is to be noted in the case of the deep well at Robinsons Ferry, on Sabine River (1120), in which a soft, pleasant-tasting water is reported at a depth of 1,010 to 1, 030 feet. Near the outcrop successful wells have been finished at Clarks (Pl. XXXVIII, sec. B) and at Weavers Spur (Pl. XXXVIII, sec. E), and a successful well could doubtless be finished at Montrose, Natchitoches Parish, by going about 100 feet deeper than the well abandoned (Pl. XXXVIII, sec. E).

In southern Arkansas and Mississippi, north of the Red River-Alabama Landing fault, a water horizon in the upper part of the undifferentiated Eocene, in about the same stratigraphic position as the basal Cockfield horizon, is very widely and extensively developed (Pls. XXXVIII, secs. A, B, G, H, K; XLI). Between it and the base of the Jackson a number of water sands have been developed in different wells, but they show little regularity, and the better wells have almost without exception been finished in the main horizon.

Pressure.—The outcrops of the Cockfield and corresponding undifferentiated Eocene water sands in Arkansas and Louisiana are all relatively low, and the water will generally not rise much over 100 feet above sea level, except in elevated regions where the head is dependent on the local height of the ground-water table. Flowing wells from this horizon will be obtained along the main stream channels in central Louisiana (Pl. XLI). In Arkansas and northwestern Mississippi the artesian area is near the eastern side of the flood plain, where a relatively higher head is possible because of the greater average height of the Mississippi hill lands. Water from these horizons will rise very near the



C = Cretaceous Outcrops   •=Flowing Wells   o=Non-Flowing W

LARGE FIGURES give depths of base of formation below sea level.

surface over all the flood plain, but in Arkansas it is regarded as quite improbable that flowing wells will be obtained.

Quality.—In central Louisiana the water of this horizon is generally impotable except near the outcrop. West of Red River, as indicated by the Robinsons Ferry well (1120), water of good quality may be expected much deeper in the embed. Indeed, it is believed that in the section west of Red River the quality of the deep water will generally be better in this horizon than in the underlying Sabine.

In southern Arkansas and northwestern Mississippi no impotable water has been reported at this horizon in any wells except at Crossett, Ark. (6). As a rule the water from the basal layers is soft and more or less alkaline. At Empire (26) the water is so alkaline that it can not be used in boilers; but at Blissville (145), Greenville (1039), Arkansas City (143), Monticello (148–150), and Wilmer (153) good boiler water has been obtained. The water from the beds just below the Jackson, as at Warren (14–19), is generally hard, and better water can be obtained by deepening the wells.

Availability.—The water sands of the basal Cockfield are relatively very persistent. They may be confidently expected in eastern Arkansas and northwestern Mississippi at depths not greatly exceeding those indicated on Pl. XLI. Failures have been relatively few, those at Rison (133) and Thornton (23) being the most noteworthy; but these are entirely surrounded by successful wells and so represent only local variations. The area affected by the impotable sulphur water encountered in this horizon in the Crossett well (6, Pl. XXXVIII, sec. B,) is probably not large, as is indicated by successful wells at Warren (19), Monticello (148–150), Dermott (24), Blissville (145), and Greenville (1039).

In Louisiana the development of this horizon is probably limited to wells near the outcrop and west of Ouachita River (Pls. XXVII, XLI). On Sabine River the dip of the strata will make the depth prohibitive at any great distance from the outcrop. Between Red and Ouachita Rivers development is restricted by the mineral water in the embed, and east of Ouachita River the absence of this horizon in the Delhi and Vicksburg wells suggests that it is of minor importance in that section.

OLIGOCENE HORIZONS

CATAHOULA WATER SANDS

The sand and sandstone beds occurring through the Catahoula formation form a very important group of horizons which have been developed in central Louisiana at Ferriday, Harrisonburg, Pollock, Alexandria, Boyce, and Zimmerman (Pls. XXXVIII, secs. A, B, C, E; XLII).

Pressure.—The head in the Catahoula sand, except possibly in the unexplored region in Vernon Parish, is seldom over 100 feet above sea level. Flowing wells may be developed in the flood plain southeast of the high hills in Catahoula Parish and along Little, Red, and Sabine Rivers (Pl. XLII).

Quality.—In central Louisiana the water is commonly soft and slightly alkaline and is, perhaps, the best of the Tertiary waters. In the basal layers, however, the water is in two cases salty—at Boyce (943) and at Ferriday (867). Whether these occurrences are due to soluble salts in the strata themselves or to brine which has leaked from near-by Cretaceous domes is not known, but it is probably the latter.

Availability.—Successful wells may be expected in most of the regions south of the Catahoula outcrop (Pl. XLII), and wells should not be abandoned until they have reached the depth indicated. Thus the Pickering well (981) is believed to have been a failure because it did not go deep enough; the chances of developing a successful well at that point at a depth of 1,200 feet or less below sea level are regarded as extremely good.

WATERS IN THE SURFICIAL SANDS AND GRAVELS

LAFAYETTE AND PORT HUDSON

The irregular beds of late Tertiary and Quaternary sands and gravels which cover the older Tertiary and Cretaceous beds throughout this region are of varying value as water carriers. As a rule, however, the surficial deposits are in the hills of relatively limited and local importance, while under the large river valleys and portions of the accompanying terraces they contain very large supplies.

The deposits in the hill lands often produce perched water tables (p. 73), which supply domestic wells and sometimes springs.

This supply is generally small and readily exhausted, and the most successful wells and the larger springs depend on the sandy Tertiary and Cretaceous beds rather than on these surficial deposits.

Along the main river valleys, however, where these sands and gravels were concentrated in early Quaternary and Port Hudson time, large quantities of water can generally be obtained. In the flood plains limited supplies can be obtained from driven wells (p. 91) of no great depth, but where large supplies are needed wells should be pushed to the main gravel beds which overlie the older Tertiary and Cretaceous strata. These can be reached at depths of from 75 to 150 feet.

Pressure.—The water head of these beds varies directly with the topography and the height of the water in the adjoining waterways. Flowing wells are not to be expected, but the water in the bottom lands will in all cases rise relatively near the surface and, because of the large supply and the coarseness of the water-bearing beds, will not be lowered readily by pumping.

Quality.—Where large supplies can be obtained the water is mineral in character; in regions where the older deposits are very calcareous, as in the greater part of the Cretaceous and parts of the Claiborne and Jackson beds, the water is of very little value, but where the underlying beds contain less mineral matter the water is of better quality and affords the most available supply over wide areas. In general the mineral content is higher in the water from these gravels than in the neighboring surface streams, but the percentage of sediment is much less.

MINERAL SPRINGS AND MINERAL WATERS

The rain water in passing through the ground tends to dissolve a portion of the soluble salts contained in the strata through which it passes. Thus all spring and well waters contain a greater or less amount of mineral matter in solution. Sometimes the dissolved minerals have a medicinal value, or the water is of so great relative purity that its use is recommended and the springs or wells are developed commercially.

Throughout Louisiana and the Coastal Plain of southern Arkansas there are many "mineral" springs and wells. Some

contain a very great amount of mineral matter in solution, and such waters should be used with great caution and only on the prescription of a competent physician. The water from all these springs is of local origin. It represents rain water which has fallen within a mile, or at most four or five miles, of the spring, and the greatest care must therefore be taken to see that the water is not polluted with harmful organic waste. Springs in large towns or other places so situated that they may receive either directly or indirectly the drainage of houses, barns, and outhouses should be carefully avoided, for if not polluted they are likely to be polluted at any time. In general, water from springs in any town or community of some size in this region is to be regarded with suspicion.

At several points in northern Louisiana and in the Coastal Plain of southern Arkansas attempts have been made to develop the spring waters. From many springs the waters are used locally and in a few cases, notably that of the Arkansas Lithia Spring near Hope, water has been shipped for some distance. The yield of the Coastal Plain springs is usually quite small, and this has been an important factor in restricting their development. Indeed, it is felt that if any large mineral water developments are to be made in the Coastal Plain portion of this section, they will have to depend on well rather than spring waters.

The following table shows some of the springs which have been partially developed, arranged alphabetically by counties:

Partial list of mineral springs in the Coastal Plain strata of northern Louisiana

No.[6]	County.	Location and name.	Character of water.	Remarks.
771	Bienville....	Kings Salt Works, Salt Springs	Brine	
772	....do.	Rayburn Salt Works, Salt Spring	....do	
814	Caddo.......	Shreveport, Currie Springs.....	Soft.........	Sold locally for drinking purposes.
	....do.	Shreveport, Mineral Wells.....	....	Sold locally for medicinal purposes.
861	Catahoula. .	Tullos, Bayou Castor Salt Spring	Saline	
864	....do	White Sulphur Springs.........	....	Local resort, largely patronized before the war.
863	Claiborne...	Lisbon, 6 miles east of.........		Local resort.
871A	De Soto.....	Grand Cane Mineral Springs...	....	Local resort, with improvements...........
888	Lincoln......	Ruston, Louisiana Chautauqua.	Iron.	
900	Natchitoches	Allen...............................	....do......	
912	Natchitoches	Natchitoches, Fourth of July Spring........................	....	Local resort.
913	... do.	Natchitoches, Iron Springs.....	Iron	
914	....do.	Natchitoches, Breazeale Springs	....	
915	....do.	Natchitoches, Sulphur Springs.	....	
016	....do.	Sans Souci........................	....	Do.
958	Red River ..	Coushatta, 10 miles east of.	Saline.	
972	Sabine.......	Pleasant Hill, Ferrell's Mineral Spring..........................	....	Local resort, with small improvements.
	....do.	Negreet Salt Springs...........	Brine	
982	Webster	Bisteneau Salt Works...........	....do......	
984	....do.	Dubberly, Valentine Springs...	Sulphureted	Noted locality for medicinal purposes.
984A	....do	Minden, Long Springs..........	Iron	Local resort.
994	Winn.	Drakes Salt Works, Salt Springs	Brine	
995	....do.	Prices Salt Works, Salt Springs.	....do......	

[6] See chapter V.

HYGIENIC VALUE OF DEEP-WELL WATERS OF NORTHERN LOUISIANA AND SOUTHERN ARKANSAS

The relatively porous character of the Tertiary beds in northern Louisiana and southern Arkansas and the irregularity of these beds render surface wells particularly liable to pollution. Even in thinly-settled regions the domestic wells are always near the house and barns and the drainage from the barn lot and outhouses goes more or less directly into them. It is extremely essential in shallow wells that there be an impervious cover to divert this refuse, and from the very nature of most of the shallow wells in this region such a covering is seldom present. When the houses are in groups, as in towns and villages, the danger increases at a very rapid rate. As a rule deep-well waters, where the mineral content is not excessive, are much to be preferred to water from shallow surface wells. An exact quantitative statement of the relative value is particularly difficult because of the impossibility of obtaining complete information. However, in

order to obtain some idea of the effect of the use of deep-well waters a circular letter was sent to persons at points where deep wells had been used for some time. This letter asked the following questions: "What was the relative amount of sickness before and after the use of deep-well water? In your town how does the general health of the people who use deep-well water compare with that of those who do not? How does the general health of your community compare with other places similarly situated, but where the people use shallow-well water?"

Definite replies to this letter were received from Pine Bluff, Ark., and Ruston, Spring Hill, Zimmerman and Boyce, La.

Pine Bluff, Ark.—The data at this point refer to the effect of the water from wells 800 to 900 feet deep, supplied by the Sabine water sand (Pl. XXXVIII, sec. B), on the employees of the St. Louis Southwestern Railway in the Pine Bluff shops. Previous to the sinking of the wells in 1897 and 1899 (410, 411) the water supply was from shallow wells. Mr. R. M. Galbraith, formerly general master mechanic of the Pine Bluff shops and now president of the Cotton Belt Trust and Savings Company at Pine Bluff, made the following statement in October, 1902:

Before the deep wells were completed 40 to 50 of the 437 men employed in the shop were on the sick list during the summer. After the deep-well water was used there was practically none on the sick list.

Ruston, La.—City water works were installed in this place in 1900-1901. The supply is from a well (890) 425 feet deep, which obtains its supply from the Sabine sands and from a thin bed in the lower Claiborne (Pl. XXXVIII, secs. C, I). Dr. R. F. Harrell reports under date of November 17, 1902:

There has been a very noticeable decrease in the number of cases of malarial sickness where the people confine themselves to the use of hydrant water. Of the 3,500 people in Ruston it is estimated that 945 are using deep-well water. We had 51 cases of typhoid fever here this year, and not one has occurred in families where the people have used deep-well water altogether.

Spring Hill, La.—The supply here is from the Sabine sands from a depth of 228 to 270 feet (989). The local manager of the Pine Woods Lumber Company writes:

The general health of our people has been immensely improved since we have used the deep-well water entirely for drinking purposes in the mills. If we could compel our employees to universally use it we could further

decrease the sickness. The percentage of sickness here is much less than in the surrounding camps and farms.

Zimmerman, La.—Drinking water for the large mill at this point is supplied by a flowing well 175 feet deep, which is supplied by one of the Catahoula sands (956). The mill is situated on an old cut-off lake of Red River into which the sawdust and waste is dumped, and on the whole the conditions are not very inviting. Mr. J. A. Bentley, president of the J. A. Bentley Lumber Company, which operates this mill, reported November 10, 1902:

Before we had the artesian well the sickness among our people at Zimmerman was quite discouraging, but since we have put in the well chills and fevers have almost entirely disappeared. The comparative amount of sickness before the well was put down was ten sick to one now.

Dr. J. H. Reagan, resident physician for the Bentley Lumber Company, both before and after the well was sunk, reports:

Before the well was put down malaria was very prevalent. There was much more sickness in Zimmerman than in the high pine-covered hills to the south. After the well was put down we had at least 30 or 40 per cent less sickness than previously. I had no typhoid and very few cases of continual fever among the people at Zimmerman; and almost my entire practice was in the neighboring hill region, where the people depended on surface water. My conversation with neighboring physicians and people from adjoining towns elicited the fact that much fever existed when Zimmerman was comparatively immune.

Boyce, La.—The water for the town and shops of the Texas and Pacific Railway at this point is supplied from a number of artesian wells (942–946), generally about 300 feet deep, which obtain their supply from the Catahoula beds (Pl. XXXVIII, sec. C). Mr. H. A. Boyce reports regarding this locality:

To my certain knowledge the health of Boyce has been greatly benefited by the use of artesian water. Referring your letter to our two physicians, Doctor Sewell and Doctor Texada, both stated the same. They have been practicing here only since the wells were bored, but from information from former physicians have no hesitancy in saying that sickness has decreased at least 50 per cent. Formerly there was considerable typhoid fever; now there is rarely a case. Doctor Sewell, who has been here three years, says he has had four cases of typhoid fever in Boyce during that time. All four cases were in one family, who used only cistern water. Doctor Texada, who has been here about the same time, has had three cases—two at a house where cistern water was used; not certain about the other. They both agree that while there has been very little sickness in Boyce this year, and no

typhoid fever, there has been considerable sickness, and many cases of typhoid fever in the surrounding country where cistern and surface waters are used. They attribute the health of the town to the use of artesian water for sanitary regulations are no better now than formerly. There has been no sickness among railroad employees this year.

HISTORY OF DEVELOPMENT

The pioneer development of the deep-well waters in northern Louisiana and southern Arkansas was in the Cretaceous region of southwestern Arkansas. Here in the fertile black lands there was no other available supply and the geologic conditions were such that deep wells could be easily and cheaply sunk. Many such wells were completed before the war, and since that time necessity and low cost have combined to make the development very active.

In the Tertiary region, on the other hand, where water could generally be obtained in shallow wells at any point, the necessity of developing the deep supply was not evident. Moreover, the difficulty of sinking such wells was greater than in the Cretaceous region and the cost therefore higher. In the Tertiary hill country the low value of the land and the absence of large industries prohibited very great expenditures for wells, and in the alluvial regions, where land values were higher, abundant water supplies could be obtained from the Port Hudson sands and gravels at depths ranging from a few to 150 feet (p. 82). Within the last fifteen years, however, many factors have combined to change this condition. The wealth of the country, which has been slowly accumulating since the civil war, has become sufficient to justify expenditures for deep wells at plantations and cotton gins in many widely separated places; ice factories have been established at many points; and compresses, cotton-oil mills, and cotton factories requiring large quantities of water have been erected. In the towns the rapid development has increased the fire risk and started the demand for waterworks, and the education of the people regarding the relation of water and drainage to health has aroused a demand for pure water. Of the waterworks thus far established, five in northern Louisiana and six in southern Arkansas depend entirely on underground water, and one in northern Louisiana and two in south-

ern Arkansas depend in part on underground water, as shown in the table below. Finally, with the great extension of the railroads, the rapid exhaustion of white-pine lumber in the Northern States, and the greater demand for building materials from all sources, large mills have been erected at many points throughout this region. These mills, demanding an abundant and steady water supply, have been a most important factor in the development of the deep-well waters in the Tertiary beds of Louisiana and Arkansas.

Waterworks of northern Louisiana and southern Arkansas, 1904

Number of well.[7]	Name of town.	Ownership.	Source of supply.
934-935	Alexandria, La	Municipal	Deep wells.
948	Lecompte, La	do	Shallow wells.
988	Minden, La	do	Deep wells.
923	Monroe, La	do	Ouachita River ; deep wells.
....	Natchitoches, La	do	Springs.
890	Ruston, La	do	Deep wells
....	Shreveport, La	Private	Cypress and Crow bayous.
....	West Monroe, La	Municipal	Ouachita River.
....	Arkadelphia, Ark	do	do.
....	Camden, Ark	do	do.
24	Dermott, Ark	do	Deep well.
321-322	Hope, Ark	do	do.
....	Hot Springs, Ark	do	Springs and surface water.
....	Little Rock, Ark	Private	Arkansas River.
148	Monticello, Ark	Municipal	Deep wells.
412	Pine Bluff, Ark	Private	do.
580	Prescott, Ark	Municipal	do.
478-479	Texarkana, Ark	Private	Shallow wells and surface water.

[7] These numbers correspond to those used in Chapter V, where additional data will be found.

CHAPTER III

METHODS AND COST OF WELL MAKING

METHODS

In wells of small diameter the three following processes are employed to break the material into pieces small enough to be readily removed from the hole: (1) Grinding or cutting with a rotary motion, (2) pounding or shattering by percussion, (3) washing or separating the particles by means of water currents. The first is illustrated in the well auger and diamond drill which cut or abrade by the rotary motion of a harder on a softer material. The second is illustrated in the cable rig, or common drop drill, which in its essential features is but a very heavy bar drill, with suitable appliances for lifting, which pounds and shatters the rock into pieces. In many applications of the grinding and pounding processes, which are used in varying combinations, water under pressure is an important accessory, and in the jetting and rotary process, used in unconsolidated sands and clays, it is of greater importance as an abrading agent than the other two.

After the material is loosened it is necessary to remove it before the drilling can proceed, and it is in the removal or disposition of this material that the different methods of well making show the sharpest distinctions. On this basis wells may be divided as follows:

A. Material from well hole not elevated to the surface.
   - I. Removal automatic.
     - a. Driven wells.

B. Material from well hole elevated to the surface.
   - I. Removal involving a cessation of the drilling or boring.
     - a. Dug wells.
     - b. Wells made with a dirt or clay auger ("bored wells").
     - c. Wells made with a well punch ("punched wells").
     - d. Wells made with a simple percussion drill and sand pump (cable rig).
   - II. Removal automatic, without a cessation of the drilling or boring.
     - a. Well made with "self-cleaning" drills,[1] or automatic sand-pumping outfit.

[1] Sometimes improperly called "hydraulic process." It is no more a hydraulic process than is the cable rig, from which it differs essentially only in the automatic removal of the drillings.

b. Wells made by hydraulic process.
  1. Jet process.
  2. Rotary process.

III. Removal only in part automatic.[2]
  a. Wells made with core drills.
    1. Diamond drills.
    2. Chilled-shot drills.
    3. Hollow steel bit coring machines.

DRIVEN WELLS

In regions of unconsolidated strata, where the ground water is relatively near the surface (within the suction limit, or about 30 feet) and the water-bearing beds are relatively coarse, the cheapest and simplest method of obtaining a small water supply is by placing a strainer on a piece of pipe of the same size and driving it into the ground with a sledge or maul. Extra pieces of pipe are added after the first length is driven into the ground, and the well is thus made the desired depth. Unless the depth at which the best water supply can be obtained is already known, tests are made from time to time by screwing a small suction or "pitcher" pump on the top of the casing. When a desirable stratum has been located, the well should be pumped continuously for some time to free the strainer and remove the finer particles from the stratum in the immediate vicinity of the screen and so form a natural strainer of greater or less extent about the well (fig. 34). This is the commonest type of well in the river-bottom lands, but in the hill lands, though it is occasionally used, better results can usually be obtained by other methods.

BORED WELLS

The principle involved in the carpenter's auger was early extended to boring holes in unconsolidated sands and clays, and it still remains one of the simplest and cheapest methods of making wells of small diameter and of a few hundred feet depth. Various types of augers are employed, some of which are shown

[2] All drillings are automatically elevated by a water jet in all types of core drills, but the removal of the core proper involves a cessation of drilling.

in Pl. XLIII, 2, 3, 4, 5. Forms Nos. 2 and 5 are adapted for use in clay and Nos. 3 and 4 for sand and sandy clay where it is desirable to have some sort of containing vessel to hold the cuttings. When small bowlders are encountered which can not be taken up by the auger, grabs of various kinds are used to remove them (see "ram's horn grab," Pl. XLIV, 1, 6); but if the bowlders or masses of rock are larger than the hole the well must be abandoned or some other form of tools employed. When the rock is thin it may be shattered by substituting a bar drill for the auger and raising and lowering, as in the cable rig.

The drill rods are of iron or wood, sometimes square (Pl. XLIII, 1), so that wrenches or other suitable turning devices can be attached, but more often round, when they are turned by a clamp or wrench (Pl. XLV). When the auger is filled with earth it is lifted to the surface with a windlass and emptied and the boring resumed. Bored wells are in some instances cased with hollow trees, but more commonly with boards, sheet-iron pipe, iron casing, or tile of some sort (Pl. XLIII, 7). Of the several forms of casing, tile properly put in is perhaps the most ideal.

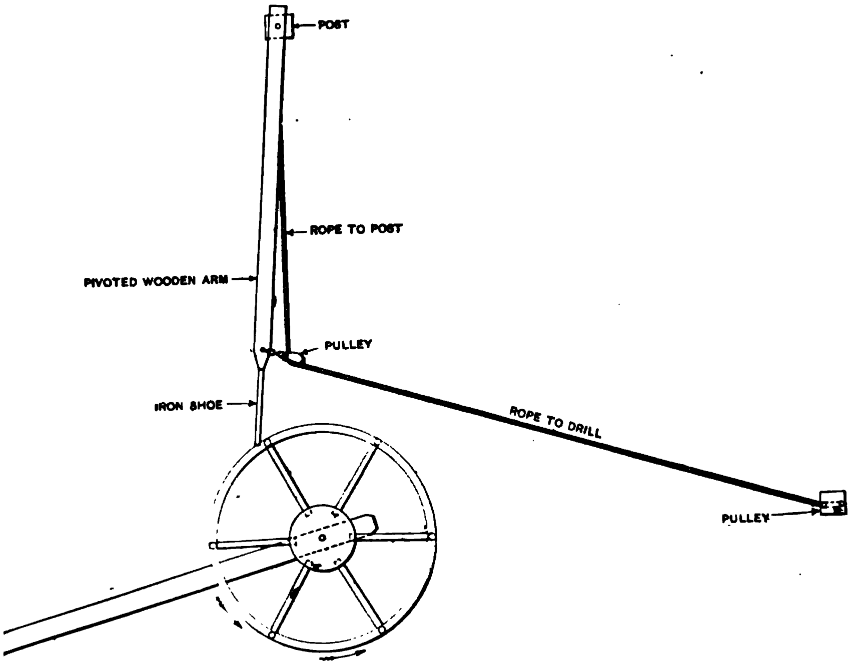
Bored wells are found throughout this region. In the Tertiary strata they are generally very shallow, but wells 100 to 300 feet can be sunk by this method. On Long Island, New York, where there is a very gravelly, sandy soil, with irregular clay masses, somewhat similar to that in northern Louisiana and southern Arkansas, the well auger is still successfully used in making wells to depths of 250 feet, notwithstanding the nearness of New York City and the ease with which improved drilling tools may be obtained. In that region the cost of wells made with the well auger and finished with tile is less than half that of wells made with improved tools, and this will probably be the cheapest method of developing domestic wells in many parts of the Tertiary strata of northern Louisiana and southern Arkansas.

ARKANSAS CLAY AUGER

In the Cretaceous region, where there are thick beds of blue clay, which do not cave, experience has developed a clay auger radically different from those shown in Pl. XLIII, though somewhat resembling a "pod auger." With this holes are very easily

'ed to depths of 300 to 400 feet at a cost of 12½ to 40 cents a t, and holes 700 feet deep have been drilled under favorable ıditions.

[he auger is 15 feet long[3] (Pl. XLIV, 14). It consists of an auger



'rom U. S. Geol. Surv.

· 31.—Method of jumping rock drill in Arkansas well rig. Compare with Pls. XLIV and XLVI.

rrel 4 feet long, which is made of cast steel and resembles a 3-:h pipe sawed vertically in half. This is fastened by a flat ce of iron to a second auger barrel, 1½ to 2 feet long; above s is a second piece of flat iron, square at the top and cut with 'eads for fastening to the wooden poles (Pl. XLIV, 11, 17). At : bottom of the auger barrel, on the right-hand side, is riveted teel cutting edge of the shape shown in Pl. XLIV, 15. This is

In Plate XLIV, this is foreshortened because of the angle at which the ;er is placed.

PLATE XLIV

[From United States Geological Survey]

TOOLS OF AN ARKANSAS WELL-BORING OUTFIT BELONGING TO MR. G. B. HIPP, OF GARLANDVILLE, ARK.

1. 9-inch "twister," or "ram's horn grab." Used for removing large stones and old wooden curbs.
2. 3½-inch bar drill, with solid iron bar attached ("drill stem"), used in drilling through the "water rock."
3. Wrench for tightening wooden poles.
4, 5. Stilson wrenches.
6. 3½-inch "twister," or "ram's horn grab." Used for removing stones, fishing for lost tools, and cleaning out old wells.
7. Pipe tongs.
8. Sand pump made of section of iron pipe. Used in removing sandy and clayey material which will not hold on the regular clay auger (No. 14).
9. 5-inch reamer or cutting bit for enlarging hole made with No. 14. It is used on same guide shown with No. 12.
10. Taper pin. Used in "fishing" for lost piping.
11. 10-foot wooden pole. Used just above the clay auger.
12. 9-inch reamer or cutting bit for enlarging hole.
13. 9-inch rock drill.
14. 3½-inch Arkansas clay auger.
15. Extra cutting edge or "cutting bit" for 3½-inch Arkansas auger.
16. Key for holding poles while unscrewing.
17. Regular 26-foot wooden pole, showing detail of lower connection.
18. Iron drill rod, sometimes used instead of wooden pole in drilling through the "water rock."

'om U. S. Geol. Surv.

TOOLS OF AN ARKANSAS WELL-BORING OUTFIT.

commonly called the cutting bit and projects inward 1¼ inches. On the opposite side and slightly above is the "auger lip," which helps to hold the dirt in the auger barrel when the tools are lifted. In operation, the auger is fastened to a short 10 foot pole (Pl. XLIV, 11) known as the auger pole, and this to the regulation 26 foot pole. The tools are turned with a clamp, and when the bit begins to choke, the tools are lifted and dropped by means of a windlass (Pl. XLV). This operation jumps the dirt up in the bit, and so frees the lower end; it is termed "making a slip." If the clay is very dry a little water is added, and with the very sticky Cretaceous clay this process can be continued until the whole length of the auger is filled with a cylinder of mud. This 15 feet of mud represents about 10 feet in depth. Usually, however, the auger is filled for only about 10 feet, representing 7 feet of depth, before lifting the tools.

When rock is encountered a bar drill is used (Pl. XLIV, 2). This is sometimes attached directly to the wooden poles and sometimes to iron poles. The drill shown is fastened to a solid piece of iron weighing about 100 pounds, which in a rough way corresponds to the drill bar of the regular cable tools (Pl. XLVII).

In the outfit shown in Pl. XLVII, 2, the drill is jumped by means of an auxiliary wheel on the windlass (fig. 31). The drill rope passes through a pulley in a post near the driller and a second pulley on a pivoted arm, and is held in the supporting post by a wooden wedge. This wedge is removed and redriven when it becomes necessary to lengthen the drill rope.

When sandy layers are encountered, which will not hold in the auger, the sand pump is used or enough clay is dumped in the hole to make the sand stick together.

In cases where wells of larger diameter are desired, or where it is necessary to enlarge the upper part of the hole for wooden casing, the 3 or 3½-inch hole made with the Arkansas clay auger is enlarged with a reamer (Pl. XLIV, 10, 12).

PUNCHED WELLS

In regions where there are uniform clay beds without rocks or bowlders, wells are often made with a well punch. This consists of a cylinder of steel or iron one or two feet long split along one

PLATE XLV

[From United States Geological Survey]

WELL-BORING OUTFIT OF MR. G. B. HIPP, OF GARLANDVILLE, ARK.

Boring with clay auger (Pl. XLIV, 14) and wooden poles. The drill poles, with auger attached, are turned with clamp as shown, and when the auger begins to choke it is lifted and dropped by the boy turning back on the windlass and letting go. This jumps the dirt up in the bit and so frees the lower end. This process is repeated until the bit is full, when it is lifted to the surface and emptied. By this method from 7 to 10 feet can be bored without emptying.

PLATE XLVI

[From United States Geological Survey]

Drilling with iron poles and rock drill. Drill is jumped by means of pivoted arm, which is pushed outward and then freed from the cogs on the upper wheel of the windlass (fig. 31, p. 93).

WELL-BORING OUTFIT OF MR. G. B. HIPP, OF GARLANDVILLE, ARK.

Boring with clay auger (Pl. XLIV, 14) and wooden poles. The drill poles, with auger attached, are turned with clamps as shown, and when auger begins to choke it is lifted and dropped by the boy turning back on the windlass and letting go. This jumps the dirt up in the bit and frees the lower end. This is repeated until bit is full, when it is lifted to surface and emptied. From seven to

From U. S Geol. Surv.

DRILLING WITH IRON POLES AND ROCK DRILL.

Drill is jumped by means of pivoted arm, which is pushed outward and then freed from the cogs on the upper wheel of the windlass, which is turned.

side and slightly spread (Pl. XLIII, 8). The lower portion is very slightly expanded, sharpened, and tempered into a cutting edge. In use it is attached to a rope or wooden poles and lifted and dropped in the hole by means of a rope given a few turns around a windlass or drum. By this process the material is forced up into the bit, slightly springs it, and so is held. When the bit is filled it is raised to the surface and emptied. When working in very dry clay, water is sometimes added to aid the bit in "picking up" the material. Thin sand layers are passed by throwing clay into the well and mixing it with the sand until the bit will take it up.

This process is not very extensively used in this region, and is not so practicable as the Arkansas clay auger.

SIMPLE DROP DRILL OR CABLE RIG

It was early learned that the raising and dropping on stone of a metal bar with a horizontal cutting edge would, if the bar was turned slightly with each stroke, produce a circular hole. This primitive device in the form of a hand drill bar is used to-day in many stone quarries. As applied to well drilling the bar was at first attached to the end of a "spring pole" made by firmly fastening the small end of a sapling in the ground and fixing a support near the base so that it inclined upward at an angle of 30° or more. The hole was drilled by the "spring of the pole," the driller keeping it in motion by pulling down on the drill rope. As the hole deepened the rope was paid out and the limit of depth was determined by the elasticity of the pole and the ability of the men to raise the tools out of the well when it was necessary to remove the accumulated drillings with a sand bucket or sand pump (Pl. XLVII, 5, 6,). In time the lifting of the tools was done by horse power and then by steam; the spring pole was supplemented by a walking beam (Pl. XLVII, 3), whose motion depended not on its elasticity but on power transmitted from an engine by means of a crank shaft. This enabled much heavier tools to be jumped, and with improved lifting devices greatly increased the possible depth of wells.

A complete "string of tools" as used in the cable rig, is shown

PLATE XLVII

[From United States Geological Survey]

CABLE RIG OR DROP-DRILL OUTFIT

1. A complete "string of tools" for a cable rig. The auger stem or drill stem is used to add weight to the drill and increase its force of impact. The jars are composed of two linked pieces of extra-quality steel having a slack or endwise motion of 6 to 9 inches (No. 2); they enable a sharp, quick, upward blow to be delivered which "jars" the tools loose when they become fast. The sinker or sinker bar is used occasionally where the well is filled with water to help sink the cable rapidly; unless placed between the jars and the bit it adds little or no force or weight to the drill.
2. "Jars" open.
3. Standard rig arranged for starting the hole or "spudding." The "string of tools" is jumped by means of a "jerk line" attached to the crank of the band wheel. As the drilling progresses the tools are lowered by gradually unreeling the cable from the "bull wheel." The casing or pipe is "driven in" with driving clamps (No. 7), attached as shown.
4. Temper screw, with cable attached. After the hole has been sunk for some depth below the derrick floor the walking beam and temper screw are used. The string of tools is jumped by means of the walking beam, and the tools are lowered as the drilling progresses by means of the temper screw.

5, 6. Sand pumps or bailers; 5, Common form with steel-flap valve; 6, form with dart valve. When the accumulations of the drilling in the well impede the progress of the drill, the tools are lifted by reeling up the cable on the bull wheel and the drillings are removed with the sand-pump. The temper screw is then wound up or "elevated," the tools lowered, and the drilling resumed.

7. Driving blocks.

in Pl. XLVII, 1, and the method of operation and construction of the derrick is illustrated in Pl. XLVII, 3-7.

For the successful operation of the cable rig, or drop-drill process, it is necessary that the material be relatively hard and brittle, and firm enough to stand up without casing. In regions where hard rock is at the surface or covered with but a relatively small amount of unconsolidated material, which must be penetrated with a casing before the drilling of the well proper begins, the cable or walking-beam rig is the cheapest and most commonly used method of sinking deep wells, but in regions of unconsolidated strata, such as the Tertiary and Quaternary beds of the Atlantic and Gulf States, drilling with cable tools is impracticable, and for large wells either the jet or rotary process should be used.

In some of the Cretaceous beds where the material is solid enough to stand up without casing the cable rig has been successfully used, as at Texarkana, Ark. (480), but even in this material better results can usually be obtained with the rotary process. Cable tools were tried at Gurdon, Ark., in the same strata geologically as at Texarkana; but here the material caved badly, and after two attempts the well was abandoned. It could have been finished to the desired depth with the proper rotary outfit.

AUTOMATIC SAND-PUMPING OUTFIT

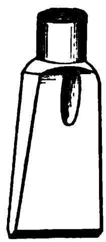
Drilling a well with a cable rig involves two principal operations—(1) a pounding up of the rock and (2) a removal of the drillings with a sand-pump. A combination of these two operations has resulted in a process which is of great value in regions of unconsolidated strata where the ordinary cable-rig process can not be used with advantage, and which is often more practicable than any other for wells of smaller diameter and comparatively shallow depths in rock regions.

The tools may be described, in the aggregate, as a sand-pump fitted with a drill having one or two perforations through which the drillings can enter the sand-pump barrel, which is composed of sections of pipe having a total length slightly greater than the depth of the well (Pl. XLVIII, 1). When this "string of tools" is "jumped" by a spring pole or walking beam, or other suitable

device, such as shown in Pl. XLVIII, 4, 5, the drill loosens the material, which, as in the ordinary sand-pump, passes through the valve into the drill rods. In drilling in dry material enough water must be added to make a rather thin mud of the drillings in order to enable them to pass the drill valve. The continuous jumping of the tools, pumps the drillings through the drill rods without regard to the depth of the well, and finally throws them out at the surface.

The principle which makes the elevation of drillings in this manner possible may be briefly explained as follows:[4]

The drill is so shaped that when it falls it tends to compress the water and air in the lower part of the hole, and, in properly shaped tools, this force is suddenly brought to a culmination by a curved surface and thus pops the valve open and allows the



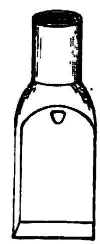


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FIG. 32.—A well-shaped self-cleaning drill. Shoulder is circular and almost completely fills the drill hole; blade is flat and suddenly curves at the top, thus developing the maximum force in the space where it is most needed to pop open the drill valve.

FIG. 33.—A badly-shaped self-cleaning drill. Shoulder does not fill the hole, and drillings rush past the opening without lifting valve with maximum force. This is, however, a very good shape for a jetting outfit.

ingress of the water and drillings. In a way it is somewhat analogous to the sudden development of pressure in the hydraulic ram, by which water is elevated to considerable heights, only here the power is developed not by the fall of a column of water, but by the gravity drop of a string of tools.

The theory of action is so intimately connected with the efficiency of the drill that it may be well to call attention to some of the features of a well-made self-cleaning drill. It should be circular at the upper end and have a diameter very slightly less

[4] I am indebted to Dr. Arthur L. Day, physicist, of the United States Geological Survey, for suggestions in this matter.

than the width of the cutting edge. The blade should be flat and suddenly curve at the top in order to obtain the effect of a conical compression in a very short space (compare figs. 32, 33). If this curved area were slightly coned toward the opening (not so much that large fragments or pebbles would be likely to jam) a further increase in force would be gained, and the maximum amount of lifting power would be developed with the least expenditure of energy. In practice additional valves opening upward, called drill rods or blind valves (Pl. XLVIII, 2, 3), are added in the drill stock. They relieve the bottom or drill valve of some of the downward thrust of the drillings, and so increase the efficiency of the outfit.

The continuous sand-pumping and the method of drilling and driving the casing at the same time, by clamping the drive block to the drill rods, make it possible to pass through beds of relatively caving material which can not be handled with the ordinary cable rig.

The important feature of this rig from a water standpoint, and the one which makes it of peculiar utility for sinking water wells in the Coastal Plain region, is that it is impossible to pass a water-bearing stratum, no matter how small, without being aware of its presence. In the jet process it is very easy to pass a water-bearing stratum, and with the rotary process, in which very muddy water is used that commonly plasters up any small sand beds encountered, the determination of water horizons, unless they are very large, is comparatively impossible.

This type of rig has been used at a number of points, notably about Shreveport, and combined with a small jetting outfit it is now supplanting the boring outfits in the deep wells in the Cretaceous region. It is peculiarly adapted for work in the Eocene beds, and will doubtless become one of the commonest forms used in the development of this section.

JETTING PROCESS

In the jetting process the material is loosened and the drillings are elevated to the surface by means of water under pressure. Its use is entirely restricted to unconsolidated materials. The water is conducted into the well by means of pipes of relatively

PLATE XLVIII

[From United States Geological Survey]

AUTOMATIC SAND-PUMPING PROCESS

1. A "string of tools" for automatic sand-pumping outfit. The drill varies somewhat in size, length, and shape, but is characterized by the presence of a leather valve which allows the drillings to enter and prevents their egress, as in the sand pump (Pl. XLVII, 5, 6). The "drill stock" or drill rods are commonly 1 to 1½ inch pipe, though in wells 3 to 4 inches in diameter a short length of 2½-inch pipe is sometimes placed above the drill.

2, 3. Drill-rod or blind valves: 2, Leather drill-rod valve, with large opening; 3, metal drill-rod valve, with small opening. One or two drill-rod valves are inserted in the drill-rods, the number depending on the character of the material being drilled. They distribute the weight of the column of drillings along the drill-rods in the downward thrust, and allow pumping to continue if anything happens to the drill valve.

4. Common device for "jumping" or "churning" the tools. The rope is given a few turns around the lifting spool or drum, and the drill pipe alternately raised and lowered by tightening and loosening the rope. This "churning" drills the hole, as in the cable rig (Pl. XLVII), and by means of the valves (1) automatically elevates the drillings through the hollow drill-rods. The casing, armed with a driving shoe (Pl. XLIX, 5), is driven in the hole made by the drill with some form of drive weight. This is lifted and dropped in the same manner as the drill-rods. Sometimes the drive block is bolted to the drill-rods and the whole weight of the tools thus utilized in driving the pipe.

5 a, b, c. Improved device, used on the "Ohio tubular well-drilling machine," for rapidly and regularly lifting the drill-rods.

6. Automatic sand-pumping, enlarging "paddy" or expansion bit, for use in unconsolidated materials.

7. Automatic sand-pumping, enlarging shoulder bit, for use in rock.

small diameter, called wash pipes, jet pipes, or drill pipes, and is directed downward near the bottom of the well by means of a suitable bit (Pl. XLIX, 3, 4; fig. 33). The drill is turned from time to time by means of a clamp or wrench, and so keeps the hole true and aids the water in wearing away more resistant masses of clay or like substances. When local hardened strata are encountered the drill is lifted and dropped, as in the drop drill or cable rig and the automatic sand-pump outfit. If there are many "shells of rock" which require to be drilled in this manner it is often advisable to insert in the drill-rods a blind valve (Pl. XLVIII, 3), upside down, with a spring to keep the valve pressed up against the valve seat in order to prevent the drillings from entering the drill and choking it when the tools are dropped.

The casing is usually driven, but in some instances it is possible to use a paddy or expansion drill (Pl. XLIX, 2, 4), which makes the hole larger than the casing and enables it to settle of its own weight when moved with a pipe wrench from side to side (Pl. XLIX, 1).

This process is better suited for drilling wells of large diameter than the automatic sand-pumping process, and is admirably adapted for use in the unconsolidated materials of the Coastal Plain.

ROTARY PROCESS

The rotary process is but a development of the jetting process, from which it differs mainly in that the more or less irregular turning of the drill-rods by hand in the jetting process is here replaced by regular and rapid turning by a revolving table or rotary moved by machinery. When the character of the material is such that the ordinary fishtail bit can be used (Pl. L, 3) the rotary process is very little different from the jetting process, except that the larger machinery, pumps, and derrick commonly used in rotary outfits permit larger holes to be drilled. The fishtail bit is used when the material does not cave readily and when the water pressure and the plastering of the sides with the mud in the wash water will make it stand up. Under favorable conditions holes may be drilled many hundred feet in this manner without casing, the bit then removed, and all the casing inserted at one time.

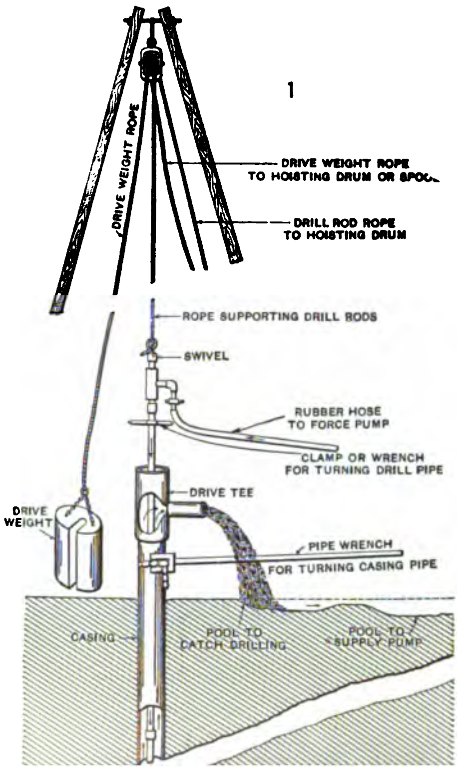
PLATE XLIX

[From United States Geological Survey]

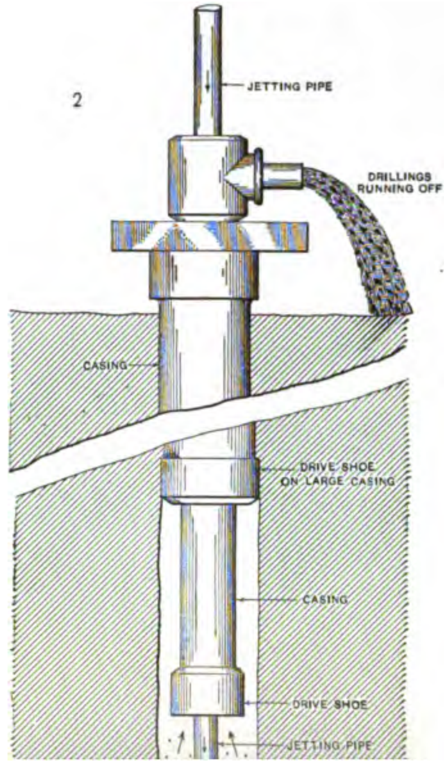
JETTING PROCESS

1. Jetting process. Water enters drill pipe or jetting pipe by hose from force pump and emerges from the two holes in the drill as jets directed downward or toward the bottom of the well. The drillings loosened by the jet and the drill, which is occasionally turned by a clamp or wrench, are carried to the surface with the upward current of water between the drill pipe and casing. If the hole is not large enough to allow the pipe to settle of its own weight when turned with a pipe wrench, it is driven with a drive block. Sometimes a solid drive head is used on top of the casing, sometimes a drive plate, and sometimes only an extra heavy tee or specially constructed drive head or tee.
2. Paddy or expansion drill in operation. This enables a hole larger than the casing pipe to be drilled, and in favorable material makes driving unnecessary.
3. Paddy or expansion drill, closed for lifting or lowering in the hole.
4. Common jetting drill. This shape, with the attachment of a valve, is often used in the automatic sand-pumping outfit, but for the best results the shape should be modified. (See p. 100.)
5. Drive shoe. Tempered steel or iron, with cutting edge, for use on end of casing pipe.
6. A simple jetting outfit. Designed and used by Roy S. Barker in drilling test holes on Long Island, New York. In this the drive weight is lifted by two men standing on a wooden platform clamped to the casing, and the weight of the men aids in sinking the casing.

1


DRIVE WEIGHT ROPE
DRIVE WEIGHT ROPE
TO HOISTING DRUM OR SPOOL
DRILL ROD ROPE
TO HOISTING DRUM
ROPE SUPPORTING DRILL RODS
SWIVEL
RUBBER HOSE
TO FORCE PUMP
CLAMP OR WRENCH
FOR TURNING DRILL PIPE
DRIVE TEE
DRIVE
WEIGHT
PIPE WRENCH
FOR TURNING CASING PIPE
CASING
POOL TO
CATCH DRILLING
POOL TO
SUPPLY PUMP

2


JETTING PIPE
DRILLINGS
RUNNING OFF
CASING
DRIVE SHOE
ON LARGE CASING
CASING
DRIVE SHOE
JETTING PIPE

The constant rotation and the high water pressure used enables the rotary to be employed in a manner entirely different from any other outfit and makes the process peculiarly fitted for penetrating very caving, unconsolidated materials. In such instances the casing, armed with a toothed cutting shoe (Pl. L, 4), is itself used for the wash pipe and the water and drillings returned to the surface between it and the wall of the hole. In practice the wash water is mixed with fine clay, and this very muddy water tends to plaster up any sand beds encountered and so prevent any loss of water and consequent reduction of head. Constant motion and water pressure are required, and in order to facilitate the addition of drilling pipe two water swivels are employed. When the hole has been drilled to such a depth that the top of the pipe is near the revolving table a length of pipe is attached to the second water swivel and elevated by means of the lifting drum into position for coupling; the rotary is then reversed and the first water swivel unscrewed, the new length of pipe is coupled on, and the pumps are switched to the hose connected with it. This operation with skillful men requires but a few seconds, and drilling proceeds with scarcely an interruption. To prevent the drenching of the men when the water swivel is unscrewed "back-pressure valves" are sometimes inserted between the pipe couplings (Pl. L, 5). To guard against accident to the pumps and the consequent "sticking" of the pipe, all large outfits have two force pumps so connected that should one fail the other can be immediately used. Wells are usually started with large casing, which is pushed down as far as possible; smaller casing is then inserted, and so on to the bottom of the well. The well at Galveston, Tex., which is the deepest well ever sunk in unconsolidated materials, has 22-inch casing from 0 to 60 feet, 15-inch from 60 to 928 feet, 12-inch from 928 to 1,500 feet, 9-inch from 1,500 to 2,363 feet, and 5-inch from 2,363 to 3,067 feet.

This process is by far the quickest method known for sinking wells of large diameter in unconsolidated material. Wells over 1,000 feet deep have in several cases been sunk in less than a day and a half. As a means of developing water wells it is not entirely satisfactory unless the exact point at which the water-bearing beds occur is already known.

PLATE L

[From United States Geological Survey]

ROTARY PROCESS

1. Rotary outfit. Water is forced from pump through water swivel and down casing or drill pipe and returns to surface as shown (Nos. 3, 4). The pipe, which is armed with a rotary shoe (No. 4) or a fishtail bit (No. 3), is constantly rotated by means of a rotary or revolving table (No. 2). The drillings loosened by the water and the drilling bit are brought to the surface by the return current outside the drilling pipe or casing.
2. Revolving table, hoisting machinery, and water swivel of Chapman's rotary.
3. Fishtail bit.
4. Toothed or rotary bit.
5. Back-pressure valve; occasionally used between couplings to keep drillings from entering wash pipe and to prevent a "back flow" when the water swivel is unscrewed to allow new lengths of pipe to be added.

CORE DRILLS

In the various types of core drills, all of which are intended for use in consolidated material or hard rock, there is a combination of a revolving and a hydraulic process. Hollow bits with some cutting or abrasive device are revolved by suitable machinery, and wear out a hole with a core standing in the center The drillings are removed by a jet of water, and from time to time lengths of the core are broken off and brought to the surface either by lifting the drill, which in some cases automatically breaks the core and clamps it, or by a separate "core lifter."

In the diamond drill a hollow bit is used in which eight diamonds (either carbons or borts) are inserted—four near the outer edge and projecting slightly outward, and four near the inner edge and projecting slightly inward.

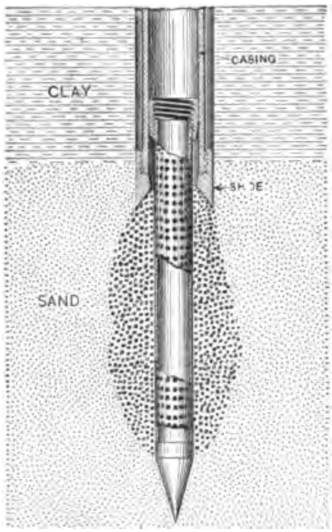
In the chilled-shot drill a hollow wrought-iron shoe is used in connection with chilled-steel shot or other loose abrasive. The constant rotation causes the shot to wear away the rock. This method can not be used in fissured or porous rocks where the shot can run out of the drilled hole, nor can it be used on bowlders or other irregular surfaces surrounded by clay, as the shot slide off and become embedded without accomplishing any work.

The toothed steel bit is similar to the ordinary rotary shoe or bit (Pl. L, 4). The rotary bit does not yield a good core because of the softness of the material worked and the rapid washing away of the core by the water current. Indeed, in most work the toothed rotary bit is fitted with a central cross-cutting edge which prevents the formation of any core whatever. This method of coring is well adapted for work in relatively soft, uniform rocks.

On account of the unconsolidated character of the material ordinary core drills can seldom be used in the Coastal Plain of Arkansas and Louisiana. Exceptional cases are found in the hard rocks encountered in some of the Cretaceous domes in northern Louisiana and in the salt and the sulphur deposits of southern Louisiana. In the latter, diamond drills have already been used.

FINISHING A WATER WELL

When the water sand is consolidated or hard enough to stand up in the hole, as in some of the Cretaceous beds, the finishing of a well offers no very great difficulty; but where not consolidated, as in the Tertiary and Quaternary beds, some sort of screen must be used. It is on the selection and setting of this screen that much of the success of the well depends. The screens commonly used are of two general types. One is made of pipe with round perforations covered with wire, wire gauze, or perforated metal gauze of some sort. The other is made of brass tubing with rows of horizontal slits increasing in size inward. The latter is perhaps the simpler, but is the more expensive type.



From U. S. Geol. Surv.

FIG. 34.—Diagram showing natural strainer of coarse material formed about the screen by pumping out the finer sand.

After the screen has been placed, which in most of the wells in this section is done after the drilling is completed, it is very desirable that the well be pumped heavily for several days or until the water clears. The point of this is to remove the finer particles immediately about the screen and thus to surround it with a natural strainer of coarser particles (fig. 34). During this initial cleaning out of the well the pump should not be stopped when it commences to draw sand. In many cases where this has been done not only has the well not been properly cleaned out or finished, but the pump valves and rods have been firmly fastened by the rapidly settling sediment and great difficulty has been experienced in their removal. In very fine sands, where there are no particles coarse enough to form a good natural screen, it is often practicable to introduce gravel from the surface and with it develop a strainer about the screen.

COST OF DEEP WELLS

The cost of wells naturally varies with the complexity of the tools needed, the skill of the driller, the character of the material drilled, the transportation facilities, and the amount of competition. If water is guaranteed it varies with the known water probabilities, and is always higher, except where the water conditions are thoroughly understood, than for a mere hole in the ground.

In the Cretaceous region of the southwestern Arkansas, where the conditions are such that deep-well water is the only supply over large areas and where very favorable geologic conditions exist, a very ingenious adaptation of the well-boring process has been developed. By this method the drillers, who are almost without exception local planters, can afford to make 3¼-inch wells for from 12½ to 40 cents a foot. When machine rigs of the jetting and automatic sand-pumping types were introduced in this region, as they have been within the last ten years, the "machine men" had to meet the competition of the "hand-tool men" and so prices have been kept down. It should be added in explanation of these prices that it is usually understood that the board for the drillers, and horse feed, will be furnished by the persons for whom the well is being drilled, who will also furnish the casing. As this is generally made of a few rough yellow-pine boards, which can be obtained at a near-by mill, it is not a very important item of cost.

In the Tertiary regions, where water can generally be obtained in shallow dug and driven wells, the demand for deep wells has not been so great. However, with the rapid development of this section in the last fifteen years, large and permanent water supplies have been demanded for manufacturing purposes and deep wells have been put down at many points. The first of these wells were put down by well drillers from other sections of the country. The cost was necessarily high, and the prices have been pretty well maintained to this time. The usual charges range from $1 to $4 a foot without casing, and while very large compared with the cost of wells in the Cretaceous region they are but slightly higher than those on Long Island, New York. The development is now largely restricted to wells for mills, ice factories, and waterworks, but conditions are very favorable for extensive

developments for domestic and plantation purposes. Small jetting, automatic sand-pumping, and hand-boring outfits[5] are well adapted for such developments, and for ordinary wells 200 to 400 feet deep they should almost entirely supplant the larger rigs. The following example illustrates the difference in cost: Wells put down in Avoyelles Parish 100 to 150 feet deep into the Port Hudson gravels by professional well drillers cost $2 to $3 per foot. Judge Morrow, of Rapides, Rapides Parish, has put down three wells 102 feet deep in the same material with a jetting machine at an average cost of 39 cents per foot.

Statistics regarding the cost of wells in this region are given in the following tables, which are based on reports from various sources. In some instances it is probable that the total cost given does not include the cost of casing, and that the amount given under "Average per foot" should be transferred to the column "Average per foot without casing."

[5] The bits shown in Pl. XLIV are much better adapted for work in the Tertiary strata than the specialized clay bit used in the Cretaceous strata (Pl. XLI, 14).

Cost of deep wells in the Tertiary and Quaternary strata in northern Louisiana.

LOCATION.						COST.				
County.	Town.	Total Depth.	Diameter.	Size and length of casing.		Total.	Average per foot.	Average per foot, without casing.	Year drilled	Remarks.
		Feet.	*Inches.*	*Inches.*	*Feet.*					
Avoyelles	Bunkie	125	4	....	....	$ 250.00	$2.00	....	1901	
do	do	158	4	....	....	522.00	3.30	....	1897	
do	do	140	4	....	....	400.00	2.86	....	1902	
do	Masura	110	6	....	....	500.00	4.54	....	1902	
do	Marksville	[6]400	6-4	....	....	1,400.00	1.75	....		
Bienville	Arcadia	540	8¼-6	Not cased.		1,500.00	2.77	$2.77	1901	
do	do	535	5-3½	....	480	...	...	2.75	1893	
Bossier	Antrim	286	4	4	286	......	4.00	....	1896	
do	do	233	6	6	233	...	4.00	....	1902	
do	Allentown	110	5	5	110	250.00	2.27	....	1899	Jetting machine.
do	Antrim	300	5	5	275	1,000.00	3.33	....	1898	
do	Benton	350	2½	2½	225	......	.	2.00	...	Automatic sand-pumping rig.
do	do	196	3	3	196	600.00	3.06	....	..	do.
do	do	170	2½	....	..	......	...	2.00	...	do.
do	Bolinger	235	4	4	170	......		2.00	1897	
do	Bossier City	350	2½	2½	80	380.00	1.09	....	1898	Automatic sand-pumping rig.
do	do	195	6-2	6 2	70 98	[7]550.00	2.82	....	..	do.
do	Curtis	197	2½	2½	100	300.00	1.52	.	1897	do.
do	Foster	210	3	3	150	300.00	1.43	....	1898	do.
do	Poole	300	4-2	....	...	......	1.65	....	...	do.
Caddo	Blanchard	185	3	3	100	......	..	1.25	1897	do.
do	Missionary	290	3-2	3 2	132 158	392.65	1.35	.	1900	do.
do	Robson	225	4	....	...	......		(?)1.00	1898	
do	Shreveport	996	4	4	(?)996	8,000.00	8.03	....	1891	Rotary Process.
do	do	280	4-2½	4 2½	83 69	500.00	1.79	....	1901	Automatic sand-pumping rig.
do	do	338	6-4	6 4	96 60	[8]1,117.50	3.30	....	1902	do.
do	do	225	2½-1½	2½ 1½	82 76	290.00	1.30	...	1901	do.
do	do	338	6-4	....	....	......	...	[9]1.50 2.00	1901	do.
do	do	201	2½	....	....	300.00	1.50	...	1893	do.
do	do	324	4-2½	4 2½	80 69	700.00	2.16	...	1901	do.
do	do	150 180 290	6 4 6 4 6-4	....	....	650.00 650.00 650.00	4.20 3.61 2.24	....	1902 1902 1902	do.
do	do	210	2½	2½	80	250.00	1.19	....	1897	do.
Claiborne	Stateline	285	3-2	.	...	365.00	1.28	....	1900	do.
Grant	Colfax	1,103	....	2½	900	2,500.00	2.26	....	1899	Rotary outfit.
do	Pollock	910	8-6-4	....	....	1,700.00	1.87	....	1896	
do	Rochelle	[10]555	....	....	....	4,300.00	7.75	[11]1.00	..	
Jackson	Hodge	330	6	6	330	1,300.00	3.94	...	1900	
do	Jonesboro	545	6	5	534	2,500.00	4.58	....	1901	
do	Wyatt	302	4	4	302	634.00	2.10	.	1902	
Lincoln	Ruston	430	8-6	8 6	200 230	1,800.00	4.19	....	1901	
do	do	450	4	4	450	1,200.00	2.68	....	1901	
Natchitoches	Natchitoches	726	6-4-2½	6	160	1,250.00	1.72	...	1900	Rotary outfit.
do	Weaver Spur	308	4 2	4	124	418.00	1.36	....	...	Automatic sand-pumping rig.

[6] Depth paid for.
[7] Amount paid drillers.
[8] Contract price with certain stipulations as to yield.
[9] First 100 feet, $1.50 per foot; below 100 feet, $2 per foot.
[10] Statement of driller.
[11] Contract price for drilling, owners to furnish everything but the drills.

Cost of deep wells in the Tertiary and Quaternary strata in northern Louisiana—Continued.

LOCATION.		Total depth.	Diameter.	Size and length of casing.		COST.			Year drilled.	Remarks.
County.	Town.					Total.	Average per foot.	Average per foot, without casing.		
		Feet.	*Inches.*	*Inches.*	*Feet.*					
Ouachita . .	Monroe. . .	360	3½	3½	360	. . . . . .	. . .	$3.00	1892	Jetting process
. . do . . .	. . do . . .	385	5	. .	. . . .	. . . . . .	. . .	3.50	1892	do.
. . do . .	. . do . .	375	5	5	375	$ 875.00	$2.33	. . . .	1901	do.
Rapides . .	Boyce . . .	302	8	. . . .	. . . .	1,200.00	4.00	. . . .	1900	Rotary process
. . do . . .	. . do . . .	279	3½	3½	180	400.00	1.43	. . . .	1899	
. . do . . .	Rapides . .	102	2		102	40.00	0.39	. . . .	1900	Drilled by owner with jet machine
. . do . . .	Zimmerman.	175	4	4	175	185.00	1.05	. . . .	1897	Drilled by owner
Red River. .	Lake End .	287½	4-2½	4 2½	85 80	[12]530.00	1.84	. . . .	1900	Automatic sand pumping rig.
Sabine . . .	Loring . . .	704	6	. . . .	. . . .	. . . . . .	. . .	3.25	1901	Rotary.
. . do . . .	Plymouth . .	521	4	. . . .	. . . .	. . . . . .	. . .	2.25	1901	do.
Union. . . .	Randolph. .	206	3½	3½	206	500.00	2.43	. . . .	1901	
Webster. . .	Minden. . .	317	6	6	317	1,000.00	3.15	. . . .	1901	
. . do. . .	Spring Hill.	368	3	3	(?)368	661.85	. . .	1.80	1899	
Winn. . . .	Tannehill . .	270	4	4	(?)270	500.00	1.85	. . . .	1902	

[12] Contract price; well not accepted because of salty water.

CHAPTER IV

UNDERGROUND WATER PROSPECTS, BY COUNTIES

NORTHERN LOUISIANA

AVOYELLES PARISH

Avoyelles Parish is almost wholly dependent for its underground-water supply on the sands and gravels of the Port Hudson and redeposited Lafayette. These deposits underlie the whole parish (Pls. XXXVIII, sec. B), and while in the bottom lands shallow driven wells are nearly always successful, the best water can be obtained in the coarser gravels between 65 and 200 feet (756–767). This supply is practically inexhaustible; and while the water is hard, a chemical and bacteriological examination by Professor Metz, of New Orleans, of the water from this horizon at Lecompte (948), where city waterworks are contemplated, has resulted in a very favorable report.

The water-bearing sands developed in the Alexandria wells are, on account of the dip, very deep under most of this parish (Pl. XXXVIII, sec. B), and it will generally be inexpedient to try to develop them. The deep wells of the Natchez and Marksville Oil Company found no important horizon below the upper gravels which supply the municipal well at Marksville (767).

BIENVILLE PARISH

Throughout all of Bienville Parish, with the exception of limited areas immediately surrounding the Cretaceous domes at Kings and Rayburns Salt Works (Pls. XXVII; XXXVIII, secs. E, I), deep-well water can be obtained in the Sabine sands. The lower limit of profitable development ranges from 150 feet below sea level in the northeastern part of the parish to about 300 feet in the southeastern part (Pl. XL). Water sands will generally be found above this extreme depth, but in case they are locally absent at any point it will not be advisable to go deeper. The clays of the Midway and Arkadelphia formations, which underlie

the Sabine, contain no water, and that of the next horizon, which is 600 or 700 feet below the Sabine, is very salty and is the source of the brine of the old salt works (Pl. XXXVIII, sec. E). This brine, in many cases, leaks into the Eocene sand beds and renders the water impotable. The prospects south of the domes are, therefore, not so good as those north.

The pressure head will vary somewhat with the local topography (Pl. XXXIX), and flowing wells are to be expected only locally and in deep valleys near high hill masses.

BOSSIER PARISH

The best water in Bossier Parish is obtained from the Sabine sands at depths not exceeding 100 to 150 feet below sea level (Pls. XXXVIII, secs. D, F, I; XL). The many wells in northern Bossier Parish have thoroughly demonstrated the possibilities there, and the well at Robson (805), in Caddo Parish, shows that good results can be expected at least that far down the river. Water-bearing sands will be found in the Sabine in the extreme south end of the parish at the depths indicated by the wells at Curtis, (789) Robson (805), and Frierson (871), but the quality can be determined only by drilling.

The water head in this region varies almost directly with the local topography (Pl. XXXIX). Flowing wells are therefore not to be expected, except locally, and if obtained will probably have a short life (778, 779, 784).

Under the Red River flood plain and the terraces accompanying it are considerable gravel deposits which yield abundant supplies of water of poor quality. This is the source of most of the water used in the bottom lands. In sinking deep wells the common practice in this region is to penetrate these gravels with a 3-inch casing, which is firmly seated in the underlying blue clay; a hole an inch or two in diameter is then drilled, which is cased but a few feet. In general it is felt that it would be better to case the wells the entire depth, using a still larger casing to penetrate the upper gravels, and to place screens opposite each of the water-bearing sands. The greatest care must be taken to cut out the water in the surficial gravels, or it will seriously impair the quality of the water obtained in the Sabine sands (797).

CADDO PARISH

The principal water-bearing horizons in Caddo Parish are (1) the Quaternary, or Port Hudson, gravels and sands, and (2) the sands in the Sabine formation (Pl. XXXVIII, secs. D, E, 1).

The Quaternary, or Port Hudson, gravels and sands underlie the Red River flood plain at depths of 75 to 130 feet (782–785, 788, 796, 799, 800, 804, 805). They supply the shallow wells in this region, and will yield very large amounts when the wells are properly finished in the gravels near the base. The water is, however, hard, chalybeate, and alkaline, and a better quality can usually be obtained in the underlying sands.

The Sabine formation underlies all of Caddo Parish, except possibly a limited region near Sodo Lake, to a depth of 100 to 150 feet below sea level. In it there are several sand beds, some occurring in fairly well-defined horizons. These beds vary somewhat in thickness from place to place, but in general may be said to be available at any point in the parish. Failures are reported at Furrh (802), Uni (835, 836), and Dixie (801), but all of these represent essentially local variations. That the Furrh well represents only a local absence of the Sabine water sands is shown by the successful wells at Shreveport, Blanchard, and Marshall (Pl. XXXVIII, sec. 1). At Uni a sand bed was encountered in the proper stratigraphic position (Pl, XXXVIII, sec. F), but yielded no water, though successful wells have been finished all about it. The well three miles south of Dixie, at the mouth of Cottonwood Bayou (801), has apparently struck one of the peculiar Cretaceous domes which occur irregularly throughout Louisiana, and which yield impotable salt water. To judge from other cases, the area affected by this disturbance is not great (p. 18). The conditions everywhere in Caddo Parish warrant sinking wells to depths of 100 to 150 feet below sea level, if water is not encountered above that point, but it is useless to continue them deeper. Below this point are the Midway and Arkadelphia clays, which contain no water, and below them is the Nacatoch sand, which contains artesian salt water (806, 871). Several deeper wells have been drilled throughout the parish, and it is popularly, though incorrectly, supposed that good water has been obtained at greater depths. At Shreveport there are several water-bearing

horizons (fig. 35), the best one being about 50 feet below sea level. The water head varies almost directly with the local topography, and flowing wells are essentially of local occurrence. Nearly all the wells in this region are cased only part of the way to the bottom. It is believed to be desirable to case them the entire distance and to place proper screens opposite each horizon.

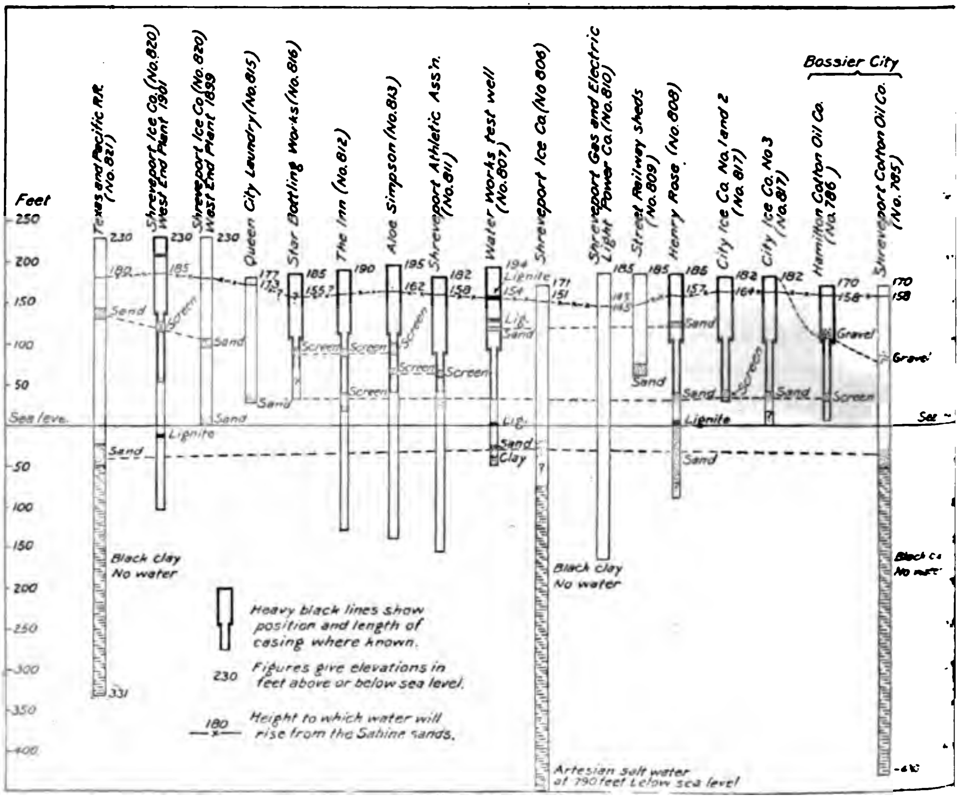


FIG. 35.—Wells in the vicinity of Shreveport, Caddo Parish, La.

CALDWELL PARISH

In Caldwell Parish large water supplies can commonly be obtained in the Quaternary sands and gravels which underlie the flood plain of Ouachita and Boeuf rivers at depths of from 25 to 100 feet (Pls. XXXVIII, sec. B.). In the hill lands shallow wells

can be finished at almost any point, though in the southern and southeastern parts of the parish, in the region of the calcareous Jackson clays, the water is very hard and the yield not always good.

Of the deep waters the best results are to be obtained in the Sabine water sands. The top of this group will be encountered at depths ranging from 200 feet below sea level in the northwestern part to 900 feet in the southeastern part. This is the horizon developed in the Columbia well (841), at the depth of 358 to 438 feet below sea level, and in the many wells about Monroe (Pl. XXXVIII, sec. B). Over all the eastern part of the parish it will furnish flowing water. This is the most promising horizon along the Iron Mountain Railway south of Columbia; it will be encountered at depths ranging from 400 feet below sea level at Columbia to 800 feet at the Caldwell-Catahoula parish line. In no case would it be advisable to go much deeper than indicated on Pl. XL.

At a distance of 400 to 500 feet above the Sabine water sand is the basal Cockfield horizon (Pl. XXXVIII, sec. B). This may be reached by surface wells in the northern part of the parish, and by deep wells in the southeastern part. It has been found in wells at Clark Spur (838–840), Ollà (856–857), Rochelle (881), and Leland (855). In all the deeper wells it furnishes impotable water, and it is not regarded as a horizon of much economic importance. Wells, except those north of the outcrop of the Jackson formation (Pl. XXVII), must be continued to the Sabine sands.

CATAHOULA PARISH

The chief underground-water supplies of Catahoula Parish are contained in (1) the Quaternary, or Port Hudson, deposits, (2) the Catahoula, (3) the Cockfield, and (4) the Sabine formations (Pl. XXXVIII, sec. B).

The Port Hudson deposits, are best developed in the lowlands along Little and Ouachita rivers and south of Catahoula Lake and Brushley Bayou (Pls. XXVII; XXXVIII, sec. B). These beds contain large supplies and are the ones most commonly developed. Shallow driven wells yield sufficient water for ordinary purposes,

and when large supplies are needed they can be obtained in the main gravel beds at depths ranging from 50 to 150 feet.

The Catahoula beds form the high sandy hills northwest of Catahoula Lake and Brushley Bayou (Pl. XXVII). Here shallow wells generally yield good soft water. These sandy beds dip regularly southeastward, and are found under the parish south of the outcrop at depths less than those shown on Pl. XLII. This is the natural source for water at Harrisonburg, and in the region along and north of Little River and Catahoula Lake, where in the lowlands flowing water will probably be obtained. There is some probability, as indicated by the Ferriday well, that in the extreme southern part of the parish salt water will be encountered. In the central portion, however, no trouble is anticipated. In the neighboring parishes the Catahoula beds supply the water at Pollock, Alexandria, Boyce, and Zimmerman. If a well does not obtain water in the Catahoula formation, it is believed to be inadvisable to sink deeper.

The next group of water sands occurs about 1,000 feet below the Catahoula (Pl. XXXVIII, sec. B) in the Cockfield formation. These have been encountered in wells at Leland, (855) Colfax, (871), Olla (856–857), and Rochelle (881), and in all these cases have yielded unsatisfactory water.

Below the basal Cockfield occur the Sabine sands, and in the northwestern part of the parish, beyond Bayou Funne Louis where the Catahoula sands are not available (Pls. XXVII; XLII) this is regarded as the most promising horizon. Successful wells have been finished in these beds at Columbia and along the Arkansas Southern Railroad from Winnfield northward (Pl. XXXVIII, secs. B, C). Its upper limit should be encountered at depths ranging from 800 feet at Olla to 1,000 feet at Georgetown or Rochelle. In no case will it be advisable to go deeper than 1,500 feet (Pl. XL). One unfavorable feature of the outlook here is the salt springs on Bayou Castor. If they represent brine leaking from one of the Cretaceous domes, it is possible that even the lowest horizon will be impregnated with salty water. In view of this, wells are more likely to succeed near the Catahoula-Caldwell Parish line than farther south.

CLAIBORNE PARISH

The conditions for deep water supplies in Claiborne Parish are very favorable. The Sabine water sands are everywhere available at depths not exceeding 200 feet below sea level (Pl. XL). Should the water sands in any case be locally absent, it is not advisable to continue wells deeper; the underlying Midway and Arkadelphia clays contain no water, and the Nacatoch sand, which lies 700 feet below the basal Sabine, furnishes salty water. (Pl. XXXVIII, sec. C, E, I). The head of the water from the Sabine sands will vary almost directly with the local topography (Pl. XXXIX), but flowing wells are likely to be developed in the bottom lands along Bayou D'Arbonne and Middle Fork.

CONCORDIA PARISH

Concordia Parish lies wholly within the flood plain of the Mississippi, and the usual supply is from the surficial gravel beds encountered at depths less than 150 feet. These yield very large supplies of somewhat chalybeate water suitable for boiler purposes.

The deep-well prospects are not very favorable; of the several early Tertiary formations, the Catahoula would be expected to yield the best water. In a number of wells at Natchez and Vidalia horizons have been developed in the upper part of this formation at depths of 300 to 500 feet. These horizons will be encountered to the south at depths which will increase about 50 feet per mile.

A deep test well put down by the Texas and Pacific Railway at Ferriday (866) obtained flowing salt water from the basal Catahoula beds at about the same horizon developed in the deepest wells at Alexandria (Pl. XXXVIII, secs. A, B). Below the Catahoula the water sands in the Cockfield and Sabine probably contain highly mineral water at this point, and it is hardly worth while to drill to them.

DE SOTO PARISH

Although but one deep well has been sunk in De Soto Parish (871), the wells in the surrounding parishes and the general geologic structure indicate very favorable conditions. Satisfac-

tory water sands may be expected throughout the parish at depths ranging from less than 100 feet below sea level in the northwestern part to 200 feet in the southeastern part (Pls. (XXXVIII, sec. F; XL). The height to which the water will rise depends somewhat on the local topography, but throughout the parish will commonly be 175 feet above sea level (Pl. XXXIX). At Mansfield it is quite likely that the height will be over 200 feet. Flowing wells may be expected locally in deep valleys flanked by high hills; the most promising region for such wells is the east-central portion of the parish, along the western edge of the Red River flood plain and in the very deep valleys tributary to it. The water will usually be soft and alkaline and the yield abundant. The town of Mansfield should have no difficulty in developing a water supply from deep wells.

In case satisfactory water is not developed at any point at a depth less than those given above, it will not be advisable to continue the well deeper. Below the basal Sabine sands are the clays of the Midway and Arkadelphia formations, and below these the Nacatoch sand, which yields artesian salt water at Shreveport (806) and Ferriday (871).

EAST CARROLL PARISH

The Port Hudson silts, sands, and gravels underlie all of East Carroll Parish to depths of from 100 to 150 feet and will yield very large supplies of rather chalybeate water. Wells to yield the greatest amount should be finished in the gravel beds which lie near the base of these surficial deposits (Pl. XXXVIII, sec. A).

The Eocene water-bearing sands can be reached at any point by drilling to the requisite depth (Pls. XXXVIII, sec. A; XL, XLI). The quality of the water is, however, very uncertain. On the one hand, there is a highly mineral water developed in the wells at Crossett (6), Delhi (962), and Vicksburg (1,037), which comes from the Sabine sands (Pl. XXXVIII, secs. A, B, I). On the other hand, there is good water in the wells at Satartia (1,045), Yazoo City (1,046–1,049), Greenville (1,039), and Blissville (145). The deep well at Lake Providence developed the same horizon found in the Empire well (26). Better water might be obtained in the Cockfield horizon at an additional depth of 200 or 300 feet (Pl.

XXXVIII, sec. A). Flowing water would doubtless be obtained at this point from the Sabine sands at a depth of about 100 feet below sea level. The water from this horizon at Yazoo City is good, at Crossett bad, and the quality at Lake Providence can be determined only by boring.

FRANKLIN PARISH

The most important water-bearing formation in Franklin Parish is the Port Hudson. This underlies the whole parish, and the coarser beds, which can commonly be developed at depths ranging from 75 to 150 feet, will furnish very large supplies of fairly good boiler water.

Of the Eocene horizons, the only one of probable importance is the Sabine. The uppermost Sabine horizon, or that encountered in the Monroe (921–925), Columbia (841), and Delhi (962) wells will be found in this parish at depths ranging from 500 feet below sea level in the western part to 1,000 feet in the southeastern part. It will probably furnish mineral water of a character varying from potable water at Monroe and Columbia to the impotable water at Delhi. This horizon at Winnsboro will be found at 700 to 800 feet below sea level and will perhaps furnish feebly flowing water. In no case will it be advisable to go deeper than indicated on Pl. XL, unless a test well several thousand feet deep is contemplated.

GRANT PARISH

The principal water-bearing beds underlying Grant Parish are (1) the surfical gravels, (2) the Catahoula sands and sandstones, (3) the Cockfield sands, and (4) the Sabine sands.

The Port Hudson gravels are of importance only in the Red River flood plain, where they will furnish large supplies at depths of from 70 to 130 feet. Less important sands are encountered above these basal gravels, in which driven wells can often be finished, but for large yields the wells should be completed in the lower gravels. Over much of the hill land there are irregular deposits of gravel, which supply local wells with very pure water. A very important development of this sort is found near Sand Spur, where a number of wells have been completed for the St. Louis, Iron Mountain and Southern Railway (882).

The Catahoula beds form the high sandy hills in the southeastern part of the parish and wherever developed yield excellent water. Several different horizons occur in this group, as shown by the wells at Zimmerman, Boyce and Alexandria, and in no case will it be advisable to go deeper than shown on Pl. XLII. Flowing water will be encountered along Red River Valley in the southwestern part of the parish 10 miles south of Colfax, and along Little River.

The Cockfield member, which outcrops in southern Winn Parish (Pls. XXVII, XXXVIII, sec. D), contains several horizons which are of doubtful value in this parish. The most important occurs near the base, or about 1,000 feet below the Catahoula. This has been developed at Colfax (877) and at Rochelle (881), and in each case has furnished artesian salty water. At Rochelle better results may be obtained in the underlying Sabine sands, which will be encountered at depths over a thousand feet below sea level, but the presence of a Cretaceous dome at Cedar Lick and the suggested presence of one at Castor Salt Springs indicate that the probabilities are against such a development though potable water has been obtained in this Sabine horizon at Winnfield (998).

The Sabine sands yield very salty water at Luella (906) and Natchitoches (909,911), in Natchitoches Parish, and as these are believed to be due in large part to salt water from the Cretaceous domes no better results can be hoped for in western and southern Grant. On the whole, in Grant Parish surface wells are the only source of underground supply, except in the region of the Catahoula formation.

The chances of getting water at Colfax by going deeper are not very promising, except at very great depths. The first Cretaceous sand, the Nacatoch, if it is present in this region, occurs about 2,000 feet below the basal Cockfield, or, roughly, 3,000 feet from the surface. This yields artesian salt-water at Shreveport (806) and Frierson (871) and will doubtless yield salt water here. In northeastern Texas, about 1,000 feet below this, is the sub-Clarksville sand, which will probably also yield salty water (Pl. XXXVIII, sec. H). One thousand feet deeper are the basal Woodbine horizons, which yield somewhat mineral water. The most

promising horizons are the Paluxy and Trinity, which, at Corsicana, Tex., according to Hill,[1] are, roughly, 500 and 2,400 feet below the Woodbine. According to this estimate, which is necessarily a very rough one, the Paluxy sand is 5,500 feet below the surface at Colfax and the base of the Trinity 7,500 feet. The cost of so deep a well would be almost prohibitive, yet it is hardly worth while starting to drill at Colfax unless some such depth is planned for.

JACKSON PARISH

The deep-well propects throughout Jackson Parish are very promising. No circumstances are known which would introduce unfavorable conditions. Wherever wells have been drilled they have yielded satisfactory results, both in this parish, as at Ansley, Hodge, Jonesboro, and Wyatt (Pl. XXXVIII, sec. C), and in adjoining parishes, as at Ruston (890,891), Monroe (921,925), Columbia (841), Winnfield (998), Tannehill (997), and Pyburn (996). (See Pls. XXXVIII, secs. B, C, I; XL).

The depth of profitable development ranges from nearly 200 feet below sea level in the western part of the parish to 500 feet in the extreme southeastern part. At Vernon a good water-bearing stratum will probably be developed at a depth of 100 feet below sea level.

LINCOLN PARISH

Abundant supplies of water may be expected throughout Lincoln Parish at depths ranging from not over 200 feet below sea level in the western part of the parish to 400 feet in the eastern part (Pl. XL). Several water-bearing horizons will be encountered above this extreme depth. Where all the sands are locally absent, it will not be advisable to go much deeper than indicated. The principal horizon developed in the Dubach and Ruston wells, and in the adjoining parishes in the Ansley, Arcadia and Monroe wells (Pl. XXXVIII, secs. C, I), occurs at depths ranging from 100 feet below sea level in the western part of the parish to 200 feet in the eastern part. The Sabine sands will furnish flowing water along Bayou D'Arbonne and Middle Fork (Pl. XI).

[1]Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pls. 69–71.

MADISON PARISH

Madison is one of the alluvial parishes, in which the most available water supply is in the Port Hudson gravels. These extend to depths of over 100 feet (Pl. XXXVIII, sec. I; wells 892–894) and will everywhere furnish large supplies of water suitable for boiler use. The deep-well prospects are very unfavorable. Artesian water can be obtained throughout the parish from the upper Sabine sands at depths ranging from 800 to 1,000 feet below sea level, but this, as indicated by the wells at Delhi (962) and Vicksburg (1037), is too highly mineral to be of use. There is little chance that the deeper water horizons will yield better results. According to the best information obtainable the well at Delta (893) should have obtained artesian salt water at 1,000 feet below sea level. The depth reported for this well is believed to be rather excessive.

MOREHOUSE PARISH

At no place in Morehouse Parish do the Eocene beds outcrop. The Port Hudson deposits, with a thin covering of alluvium in some places, form the whole surface of the parish and underlie it to depths of from 50 to 200 feet. These beds are coarser in their lower portions and will furnish very large supplies of slightly hard, chalybeate water, which is fairly good for boiler use (896–899).

No wells have yet been sunk in this parish below these surficial beds, but water may be developed in the underlying Eocene sands in all parts of the parish. South of the Alabama Landing fault line (p. 60) water can be developed in the same horizon that is found at Monroe and Delhi (Pl. XXXVIII, sec. B, I) at depths ranging from 200 to 400 feet below sea level in the western part of the parish to 700 to 900 feet in the southeastern part. The quality of the water will be between that at Monroe (921–924) and Delhi (962) and will flow over most of the bottom lands. North of the Alabama Landing fault line the basal Cockfield horizon will be encountered at depths between 300 to 400 feet below sea level. This horizon furnishes sulphur water at Crossett (6) and good water at Blissville (145), Dermott (24), and Greenville (1039). Its quality in northern Morehouse Parish could be

determined only by drilling, but it will probably be mineral. A lower horizon can be reached in this portion of the parish at depths between 800 and 1,000 feet. This is the stratum which furnishes salty water at Crossett (Pl. XXXVIII, sec. B), and there is no reason to hope for better results here.

NATCHITOCHES PARISH

Natchitoches Parish presents in surface outcrops a very singular combination of five of the six most important water-bearing formations of northern Louisiana and southern Arkansas; nevertheless it is a region in which good water can be obtained only with difficulty.

The Port Hudson gravels are well developed under the Red River floodplain, where they extend to depths of about 150 feet. When the underlying beds are not calcareous, as in the portion of the valley about St. Maurice, the water is a fairly good chalybeate water, but to the south, where the underlying clays belong to the calcareous Claiborne and Jackson groups, the water is very hard and cisterns are commonly used.

The Catahoula formation outcrops in the southern part of the parish (Pls. III, XLIII) and near the Vernon Parish line will be available in deep wells. This group of sands has been developed in the adjoining parish of Rapides at Zimmerman, Boyce and Alexandria (Pl. XXXVIII, sec. E). As yet no deep wells have been sunk in this formation in Natchitoches Parish.

The Cockfield member outcrops in a narrow belt in T. 7 N. Rs. 8 and 9 W. (Pl. XXVII.) It furnishes good water where developed at Weaver Spur (917) near the outcrop, and it is the most promising horizon at Montrose, where it will be encountered at a depth of about 600 feet (Pl. XXXVIII, sec. E). This horizon dips southeastward and is encountered at a depth of 1,100 feet at Colfax, where it furnishes artesian salt water (Pl. XLI).

The underlying Sabine sands (Pl. XXXVIII sec. E) are of value only in the extreme west-central portion of the parish, beyond the area of contamination from the salt water that leaks from the Cretaceous domes at Drakes, Prices, Rayburns, and Kings (Pls. III, XXXVIII, sec E; XLI). Near Natchitoches there is a layer in the very uppermost part of the Sabine, just below

the Claiborne, which is of local importance. It outcrops in the hills just south of Grande Ecore on Red River, and supplies the numerous springs north of Natchitoches, as Camp Salubrity Spring, Breazeale Spring, Iron Spring, and Fourth of July Spring. It is the horizon developed in the shallow wells at the waterworks (910), and encountered between 98 and 108 feet in the normal school well (911). The lower horizons, which are not interrupted by Red River (Pl. XXXVIII, sec. E), yield very salty water, which will flow in Red River Valley. These have been developed at Luella (906) and Natchitoches (909, 911), and in the adjoining Red River Parish at Lake End (960). Only in the extreme west-central portion of the parish about Marthaville and Robeline are the conditions in the Sabine sands regarded as favorable. Here, on account of the high land in northern Sabine and De Soto parishes, the direction of deep underflow is toward Red River Valley, and the head is so much higher that it prevents the inflow of the salt water from the north. Artesian water of good quality is reported at Boleyn (901) at a depth of 412 feet, and similar developments are to be expected in the same region.

At Drakes Salt Works, in the northern part of the parish, and at the salt works in the adjacent parishes of Winn and Bienville, the uppermost water horizon of the Cretaceous series, the Nacatoch sand is exposed and furnishes salt water (Pl. XXXVIII, sec. E). The brine escaping from these domes is, in part, responsible for the salinity of the water in the Sabine sands, and the prospects in northern Natchitoches for good wells in these sands are not very favorable; water-bearing beds will, however, be encountered at about the depth shown on Pl. XXXVIII sec. E.

The poor quality of the deep-well water in the greater part of this parish makes it desirable to ascertain what can be found in the underlying Cretaceous deposits. At Natchitoches, according to the best data at hand, the Nacatoch sand is 1,500 to 2,000 feet from the surface. This yields artesian salty water at Shreveport (806) and Frierson (871). In northeastern Texas about 1,000 feet below the Nacatoch is the sub-Clarksville sand, which will probably yield salty water. One thousand feet deeper are the basal Woodbine horizons (p.24), which will yield somewhat mineral water. The most promising horizons are the Paluxy

and Trinity, which, at Corsicana, Tex., according to Hill,[2] are, roughly, 500 and 2,400 feet below the Woodbine. According to this estimate, which is necessarily a very rough one, the base of the Trinity at Natchitoches is about 6,000 feet from the surface, and the Paluxy 4,000 feet. The cost of so deep a well would be very great, yet it is hardly worth while starting to drill at Natchitoches unless some such depth is planned for. Such a deep test well might be undertaken by the cooperation of the State, the parish, the town, and the railroads of that section, for all would be benefited by the results obtained.

OUACHITA PARISH

Ouachita Parish is half hill land and half alluvial land. In the hills shallow wells yielding sufficient water for domestic and small plantation uses can be finished at almost any point. In the bottom lands inexhaustible supplies of slightly hard chalybeate water are to be obtained from the surficial Port Hudson gravels, which underlie this section of the parish, at depths, of 100 to 150 feet.

The Sabine sands underlie the whole parish and will be encountered at depths of from 200 to 400 feet below sea level (Pls. XXXVIII, sec. B, I; XL). In all the alluvial land and in some of the larger valleys of the hill land this water will flow. It has been extensively developed about Monroe (921, 924), where it furnishes a soft alkaline water which is extensively used by the industries at that place and by the large plantations. The water will probably be less mineral in the western portion of the parish than in the eastern.

RAPIDES PARISH

The principal sources of underground-water supply in Rapides Parish are (1) the Port Hudson gravels, (2) the very late Tertiary gravels, and (3) the Catahoula formation.

The Port Hudson gravels are well developed under the Red River flood plain and some of the terraces along it (Pl. XXXVIII, sec. B). The coarser beds are reached at depths of 100 to 150 feet (937, 940, 947, 948, 952), though shallower wells can often be

[2] Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pls. 69-71.

finished. This horizon yields good boiler water, and the tests at Lecompte (948) indicate that it is a very satisfactory quality for municipal purposes. Much of the hill land is covered with late Tertiary gravels, and in the southern part of the parish these are sometimes of sufficient thickness to be of considerable importance as sources of water.

The Catahoula formation is the source of the deep water developed at Zimmerman (956), Boyce (942–946) and Alexandria (933—939; Pl. XLII, secs. B, C). In all the northern part of the parish except in the immediate vicinity of Colfax, where they are absent, these beds will furnish the best water obtainable. The principal horizons are encountered from 400 to 500 feet above the base, and the ordinary depth of wells will be about 500 feet less than that given on Pl. XLII, which refers to the base of the formation. It will not be advisable in any case to go below the Catahoula. Flowing water is to be expected in Red River Valley and in the extreme northeastern portion of the parish about Catahoula Lake.

RED RIVER PARISH

In the hill lands of Red River Parish there has as yet been no demand for very large water supplies, and surface wells have furnished all the water needed. In the more thickly settled region, along Red River Valley, large supplies have been easily obtained from the Port Hudson sands and gravels, which underlie the whole flood plain and furnish, from the lower, coarser beds, at a depth of about 100 feet, unlimited supplies of hard water which is fairly good for boiler use.

The water-bearing sands of the Sabine, which underlie the whole of the parish, have been developed at only one point, Lake End (960), where they have yielded salty water. The quality of the water in these beds in other portions of the parish can be determined only by drilling. In the northeastern and eastern portions, in the direction of the Cretaceous domes (Pl. XL), they are likely to yield salty water; but in the northwestern and western portions the chances are somewhat better because, west of Red River, the greater head (Pl. XXXIX, p. 126), will prevent an inflow of salty water from the fractured Cretaceous beds brought

up in the domes north of Red River. The Many dome is probably not a disturbing factor. Wells near the western side of the Valley, or in the steep creek valleys tributary to it, may furnish artesian water.

In developing these beds it is not advisable to go deeper than 100 to 200 feet below sea level (Pl. XL), unless it is planned to sink a very deep test well. The prospects along this line have been discussed under Natchitoches Parish (p. 125). At Coushatta the lower beds will be reached at a depth of about 700 feet less than at Natchitoches.

RICHLAND PARISH

In Richland Parish, as in the other parishes east of Ouachita River, large supplies can be obtained in the surficial and Port Hudson deposits, which underlie the whole region. Wells can commonly be finished at depths of from 25 to 50 feet, but where large supplies are desired it is generally advisable to go to the coarse gravels which overlie the older Tertiary beds. These beds are commonly encountered at a depth of 100 to 150 feet.

Artesian water from the Sabine sands may be obtained in any part of the parish by going to the requisite depth, which will usually be from 400 to 500 feet below sea level in the western and southwestern portions of the parish and 700 feet in the extreme eastern portion. This horizon is developed at Monroe (921—924), Columbia (841), and Delhi (962; Pl. XXXVIII, secs. B,I). The quality of the water at any point may be roughly predicted by its position relative to these three localities. Along Bayou Lafourche and Boeuf River, in the west central and south-western portions of the parish, the chances are sufficiently good to warrant sinking deep wells. In no case will it be advisable to go below the depths given on Pl. XL, unless a test well 4,000 to 6,000 feet deep is planned.

SABINE PARISH

In Sabine Parish, in the region north of the Cockfield member (Pls. XL, XLI), the best water horizons are in the Sabine sands. These have been developed at Noble, Zwolle, Plymouth, Loring, and Negreet (Pl. XXXVIII, sec. F). With the possible exception of

the Negreet well, the water obtained in each of the above cases is to be recommended rather then the surface water, which is commonly used about the mill towns. It is certainly less likely to be contaminated, and the mineral matter does not appear to be greater than in other wells where good results have been obtained. These sand beds vary considerably from point to point, but may be said, in general, to be available at any locality.

Flowing water has been obtained from this group of horizons at Boleyn (901), on Bayou Negreet (969), and at Robinsons Ferry (1120), and is likely to be developed in deep wells in the northeastern part of the parish and along Sabine River. Deep in the embed and south of the Bayou Negreet Salt Springs the water is highly mineral, but in the whole southern part of the parish where this occurs water can be obtained from the Cockfield member or in the upper part of the Claiborne. These beds cross the parish in a narrow belt just south of Many (Pl. XXVII) and dip southward. At Robinsons Ferry a soft artesian water has been obtained at a depth of 1,010 to 1,030 feet (Pl. XXXVIII,) sec. F). This is regarded as a horizon of probable importance in southern Sabine Parish (Pl. XLI).

TENSAS PARISH

This is an alluvial parish in which the best water is obtained in the Port Hudson gravels. These are commonly encountered at depths varying from 100 to 150 feet, and yield large supplies of chalybeate water. No deep wells have been sunk, though the conditions are favorable in the area shown on Pl. XLII, in which the base of the Catahoula is from 0 to 500 feet below sea level, and in wells not over 400 feet deep along Mississippi River below this belt. In the first case it is hoped to develop the lower Catahoula sands found in the Catahoula Shoals and Leland wells (Pl. XXXVIII, sec. B); and in the second to develop the upper Catahoula sand found in the Port Gibson and Natchez wells (Pl. XXXVIII, sec. A) which are supplied by a lateral westward flow from the Mississippi region. Deep wells in the southern part of the parish as indicated by the Ferriday well (866), will probably obtain salt water.

UNION PARISH

The deep-well prospects are very favorable throughout Union Parish. Two successful wells have been developed at Randolph (979), and the wells in the adjoining parishes at Dubach (889), Ruston (890–891), and about Monroe (921-927) clearly indicate the conditions to be expected (Pl. XXXVIII, secs. B, C, I). South of the Red River-Alabama Landing fault line, water will be encountered at depths ranging from 100 to 300 feet below sea level and in no case will it be advisable to go deeper than shown on Pl. XL, or 200 feet below sea level in the western part of the parish and 500 feet below in the eastern part. Flowing water is to be expected along Bayous D' Arbonne, Cornie, and L'Outre and their principal tributaries. At Farmerville the horizon developed at Randolph, Dubach, Ruston, and Monroe will be encountered at about 200 feet below sea level. North of the fault, water can be obtained in the upper Eocene or Cockfield sands at 0.300 feet below sea level, but it will not be advisable to try to develop the lower sands, as the wells at Crosset (6) and Bearden (628) obtained very unsatisfactory water from this horizon (Pl. XXXVIII, secs. B, C).

VERNON PARISH

With the exception of that obtained in the surficial gravels, the underground water supply of Vernon Parish is to be obtained from the Catahoula beds (p. 128). This formation yields good results at Zimmerman, Boyce, and Alexandria, in Rapides Parish, and near Rockland, Tex.

In Vernon Parish but two deep wells have been sunk; that at Hawthorn (980) is reported as successful and that at Pickering (981) as unsuccessful. It will be seen from the dip shown on Pl. L that the Pickering well lacked about 100 feet of reaching the horizon developed at Hawthorn. Between the Hawthorn horizon and the extreme depth shown on Pl. XLIII several water-bearing sands are to be expected which will yield good soft water. In the hill lands along the Kansas City Southern Railway water will not flow, but on Sabine River below Bayou Toro flowing wells are to be expected. It is believed to be inadvisable to go deeper than shown on Pl. XLIII, as the water in the underlying Cockfield and Sabine sands will probably be salty.

WEBSTER PARISH

In Webster Parish, except in the limited area around and south of the Cretaceous dome at the Bisteneau Salt Works (Pls. XXXVIII, secs. C, I; XL), very good water can be obtained from the Sabine sands at depths less than 200 feet below sea level. The main water horizon, as developed in the wells at Taylor (139–140), Spring Hill (989), Cotton Valley (938), Minden (985–987), and near Shreveport, is about 100 feet below sea level throughout the parish. Above this sand a minor horizon has been developed at Allentown (775) and in the ice factory and cotton-oil mill well at Minden (988). The failure at yellow pine is due to the disturbance of the Bisteneau dome, which directly affects only a small area. Good water can probably be obtained at Lanesville and Dubberly at the depths indicated by the Minden well.

WEST CARROLL PARISH

Throughout West Carroll Parish the Port Hudson deposits are very near the surface. They form the Bayou Macon hills and in the bottom lands are overlain by but a thin covering of alluvium. These beds are from 100 to 150 feet thick, and the coarser beds near the base will yield very large supplies of somewhat hard chalybeate water.

No wells have as yet been sunk below these gravels, but in every part of the parish water can be obtained in the underlying Eocene beds. South of the Alabama Landing fault line water can be had in the horizon developed at Monroe (921–927), Delhi (962), and Vicksburg (1037), at depths between 300 and 500 feet below sea level (Pl. XXXVIII, secs. A, B, I). This water will probably flow, but, as indicated by the Delhi and Vicksburg wells, will be highly mineral. Other horizons may be developed for several hundred feet below this one, and will probably also yield mineral water.

North of the fault line the basal Cockfield, or upper Eocene water sands, will be encountered at depths between 400 and 500 feet below sea level. This horizon furnishes sulphur water at Crossett (6; Pl. XXXVII, sec. B), and good water at Blissville (145), Dermott (24), and Greenville (1039; Pl. XXXVIII, sec. A). Its quality in northern West Carroll Parish can be determined

only by drilling. Two hundred feet below this horizon is that developed in the Empire and Lake Providence wells (Pl. XXXVIII, sec. A). A lower horizon can be reached in this portion of the parish at depths between 800 and 1,000 feet. This is the stratum which furnishes salty water at Crossett (Pl. XXXVII, sec. B), and there is little reason to hope for better results here.

WINN PARISH

The three important water-bearing formations available in Winn Parish are (1) the Nacatoch, (2) the Sabine, and (3) the Cockfield. The Nacatoch is commonly from 1,000 to 2,000 feet below sea level in this region, but is folded up in the Cretaceous domes (Pl. XXXVIII, secs. C, I). It yields salty water, which, leaking from the fractured and truncated domes, fills the Sabine sands to the southwest.

The Sabine formation, which occurs about 700 feet above the Nacatoch, and is from 500 to 900 feet thick, likewise underlies the whole parish (Pl. XXXVIII, sec. C; XLI). In the region north and east of the domes the sands in this formation yield good fresh water, which at Winnfield (998) is artesian. South and southwest of the Cretaceous domes these sands are present, but, as shown at Luella (906) and Natchitoches (909—911; Pl. XXXVIII, sec. E), they will probably yield salty water, though the exact limit of the brine impregnated areas can de determined only by drilling.

The Cockfield member outcrops in a belt extending across the parish south of St. Maurice and Winnfield (Pls. XXVII, XLI). Along the outcrop these beds will probably yield potable water at depths varying from a few feet at the northern edge to 500 feet near the Cockfield-Jackson contact (Pl. XXXVIII, sec. C). In the embed, as shown at Rochelle 881 and Colfax 871, this horizon will yield salty water.

Wells and springs in

LOUISIANA

No.	Location.	Town-ship.	Range.	Sec-tion.	Owner.	Driller.	Authority.
	AVOYELLES PARISH.						
1756	Bunkie	1 S. .	3 E .	. . . .	General	. . . .	Postmaster . .
757	. . . do.	1 S. .	3 E .	. . . .	Bunkie Compress and Warehouse Co.	. . . .	Bunkie Compress and Warehouse Co.
*758	. . . do.	1 S. .	3 E .	. . . .	Union Oil Co. . .	. . . .	Union Oil Co.
*759	. . . do.	1 S.	3 E .	. . . .	Bunkie Ice and Bottling Co.	. . . .	C. J. Pope, president.
760	. . do.	1 S. .	3 E .	. . . .	Texas and Pacific Rwy.	. . . .	G. W. Reiter, pumpman.
761	Bunkie, 1 mile west of.	1 S. .	3 E .	. . . .	——Sentell	L. B. Hart Well Co.	L. B. Hart Well Co.
762	Cottonport. . . .	1 S. .	4 E .	. . . .	Lemoine Brothers.	. . . do	. . do . . .
*762A	Eggbend	. . . .	. . . .	. . . .	T. L. Grimes. . .	. . . .	T. L. Grimes. .
763	Mansura.	1 N .	4 E .	. . . .	Emil Regard . . .	. . . .	Emil Regard. . .
764	. . . do.	1 N .	4 E .	. . . .	Regard cotton gin	L. B. Hart Well Co.	L. B. Hart Well Co.
*765	Marksville.	2 N .	4 E .	. . . .	Natchez and Marksville Oil Co.	W. B. Sturm . . .	A. W. Myers, foreman.
*766	. . . do.	2 N .	4 E .	. . . .	General	. . . .	C. P. Couvillion .
*767	. . . do.	2 N .	4 E .	. . . .	Corporation . . .	Andrews Well Co.	. . . do . . . . . .
	BIENVILLE PARISH.						
*768	Arcadia	18 N .	5 W .	. . . .	Vicksburg, Shreveport and Pacific Rwy	Andrews Well Co.	H. P. Touzet, foreman for Andrews Well Co.
768A	. . . do	18 N .	5 W .	. . . .	Levy Compress Co.	Will A. Strong . .	Will A. Strong . .
*769	. . . do	18 N .	5 W .	19. . .	Dr. J C Christian	. . . .	Dr. O Lerch[3].
*770	Jamestown	15 N .	8 W .	. . . .	John Gigleux. . .	John Gigleux. . .	John Gigleux. .
*771	Kings Salt Works .	15 N .	8 W .	34-35 .	H. P. Wardlaw. .	. . . .	A. C. Veatch[4]. . .
*772	Rayburns Salt Works.	15 N .	5 W .	34 . .	A G. Whitlow . .	. . . .	A. C. Veatch[5]. .
	BOSSIER PARISH.						
773	Alden Bridge . . .	20 N .	13 W .	34[6] . .	Whited & Wheless	L. B. Clifford Well Co.	L. B. Clifford . .
*774	. . . do.	20 N .	13 W .	34[6] . .	. . . do	. . . do	. . . do . . . . . .
775	Allentown	18 N .	11 W .	11[6] . .	Allen Brothers & Wadley.	. . . .	Allen Brothers & Wadley.
*776	Antrim	22 N .	13 W .	27[6] . .	Antrim Lumber Co.	L B. Clifford Well Co.	Thos. A. Antrim, president.
777	Arkana	. . . .	. . . .	. . . .	Trigg Lumber Co.	. . . do	L. B. Clifford . .
*778	Benton	20 N .	13 W .	30[6] . . .	W. H. Smith & Son.	J. P. Clifford. . .	W. H. Smith. .
779	Benton, 1 mile north of.	. . .	. . . .	. . . .	Lone Star Mill . .	. . . do	J. P. Clifford. . .

* For additional data see "Descriptive notes," following this table.

1 Numbers up to 156 refer to Arkansas localities and hence are not given in this report. The location of many may be seen on Pl. XXXVII.

2 See note.

3 Geology and Agriculture of Louisiana, pt. 1, 1892, pp. 46-47.

northern Louisiana.

NORTHERN)

Diameter of well	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	YIELD PER MINUTE. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*			
...	12-40	....	....	......	....	.....	......	.....	....
4	180	65	— 10	......	....	66	Quaternary ..	.....	....
4	158	....	— 8	.....	....	50	...do ..	Hard, alkaline.	....
4	140	....	— 16	115-140	....	100	...do ..	Hard.	Strainer, 16 feet .
4	142	} ...	— 13	......	....	.....	...do ..	.....	....
4	90								
...	135	....	— 10	......	....	.....	.. do ..	Hard.	2 wells ......
...	135	....	....	......	....	.....	...do ..	.. do ..	....
...	35-60	....	....	......	....	.....	.do ..	. do ..	....
6	110	....	— 32	......	....	140	...do ..	Alkaline; magnesia.	....
...	135	....	....	......	....	.....	...do ..	.....	....
16	1,282	85	....	42-132 243-259 452-523	....	40	Quaternary	Hard.	....
...	40-150	....	....	40 45 65	....	Small. Large.	Quaternary ..	Hard. .	....
6-4	[2]290	82	— 42	......	....	100	......	Brackish	Public well; used fo stock.
8-6	540	363	—130	40 150 165 415-465 535-540?	...	53	Sabine ..	Hard. .	Supplies water tank pumped with air lif
5-3½	535	370	—136	435	....	.....	...do ..	Soft...	Casing and strainer, 480 feet.
...	.....	....	....	......	....	.....	......	..	Mineral well ...
2	145	235	....	142	....	.....	Sabine ..	Hard. .	....
3[?]	136	160	— 2	}	....	.....	Nacatoch	Brine. .	Salt manufactured from 1840 to 1865.
36	10-20	160	....						
...	10-20	....	....	......	....	.....	...do ..	.....	Salt manufactured from 1840 to 1877.
4	286	209	— 30	140-160 260-286	....	 42	Sabine .. ...do ..	Strongly alkaline. Good[7] ..	In red sand.... In gray sand ...
6	233	211	....	120-140 230-233	....	 125	...do . ...do ..	.. Good[7] .	.... In gray sand ...
5	110	....	— 9	......	....	.....	...do ..	Soft . .	Used for boilers in saw mill ...
5	300	255	— 6	160-263	....	.....	...do ..	.. do ..	Fine for boilers and drinking
3	110	....	....	......	....	.....	......	..	Completed in 1896
2½	350	215	8—20	......	....	Large.	Sabine ..	Soft . .	Completed in 1899
3	196	215	(8)	......	....	.....	...do ..	.....	Water above a bed of lignite.

[4] Geological Survey Louisiana, Rept. of 1902, pp. 76-80.
[5] Op. cit., pp. 71-75.
[6] In town.
[7] Also reported "a little hard."
[8] Flowed for a short time.

Wells and springs in

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	BOSSIER PARISH—continued						
780	Benton	....	....	....	...do	...do	...do
781	Benton, 4 miles east of.	....	....	....	Hanks Sawmill.	...do	...do
*782	Bolinger	23 N	13 W	34	S. H. Bolinger & Co	L. B. Clifford Well Co.	....
*783	Bossier City, 3 miles north of.	....	....	....	Cash Plantation	A. L. Pullin	A. L. Pullin
*784	Bossier City, 2½ miles north of.	....	....	....	Benj Gray	A. L. Pullin	A. L. Pullin
*785	Bossier City	....	....	....	Shreveport Cotton Oil Co	....	....
*786	...do	....	....	....	Hamilton Oil Mill Co	Stoer & Backus	Stoer & Backus
787	Bossier City, 5 miles southeast of.	....	....	....	J. H. Fullilove	...do	J. H. Fullilove
*788	Collinsburg, 8 miles south of.	21N	14W	....	Will Sentell	....	....
789	Curtis	17N	13W	....	A. Curtis	....	A. Curtis
790	Curtis Station	17N	13W	....	...do	....	....
791	Foster Station	18N	13W	....	J. F. Foster	....	J. F. Foster
792	Foster Station, 1 mile north of.	18N	13W	....	J. M. Foster Planting Co	....	J. M. Foster Planting Co.
793	Haughton	18N	11W	....	R. L. McAnn	Stoer & Backus	Stoer & Backus
794	Pool	15N	11W	....	Connell, Moss & Co	...do	...do
	Red River Valley	....	....	....	General	A. L. Pullin	A. L. Pullin
	CADDO PARISH.						
*795	Belcher	20N	14W	5	Glassell Brothers	A. L. Pullin	A. L. Pullin
*796	...do	20N	14W	5	John Glassell	...do	...do
*797	Belcher, 3 miles northeast of.	21N	14W	34	Colonel Swan	...do	...do
798	Blanchard	18N	15W	3	R. T. Coal & Son	...do	R. T. Coal
*799	Dixie	20N	14W	29	M. A. & J. D. Dickson	....	....
*800	Dixie, 2½ miles east of.	20N	14W	26	John Sentell	A. L. Pullin	A. L. Pullin
*801	Dixie, 3 miles southwest of.	19N	15W	2	Glassell & Adger	...do	E. M. Adger
*802	Furrh	....	....	....	Furrh & Co	...do	A. L. Pullin
*803	Missionary	23N	14W	4	W. B. Means	Stoer & Backus	Stoer & Backus
*804	Red River Valley	....	....	....	General	A. L. Pullin	A. L. Pullin

*For additional data see "Descriptive notes," following this table.
[1] Flowed for a short time.
[2] Water lowered on pumping to 30 feet below the surface.

northern Louisiana—Continued.

NORTHERN)—Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
3	140	215	— 8	. . . . . .	. . . .	. . . .	. . .do . .	. . . . .	. . . .	780
2½	170	215	. . . .	. . . . . .	. . . .	. . . .	. . .do . .	Soft . .	. . . .	781
3 4 4	235 235 315	309	— 40	162-235	. . . .	Large.	. . .do . .	do . .	Used for mill and drinking; temperature, 64° F.	782
3	330	177	— 35	50-130 155-160 180-185 315-330	. . . .	Large. 20	Quaternary Sabine . .	Hard. . do . . Bad . . Good .	Completed in 1898; casing, 120 feet.	783
2½	330	175	[1]— 28	300-330	. . . .	10	Sabine . .	Slightly hard.	Completed in 1898; casing, 80 feet.	784
4	600	170	[2]— 30	225-235	. . . .	. . . .	. . .do . .	. . . .	No water below 235 feet.	785
6-4	195	170	[2]— 12	147-159	. . . .	. . . .	. . .do . .	Hard .	Screen placed from 147 to 159 feet; end of casing at 169 feet.	786
2½-1	210	164	[3]— 12	172-210	. . . .	10	. . .do . .	Iron, alkaline.	Temperature, 66° F.	787
2½	600	195	— 15	30-120- 232-240-	. . . .	. . . .	Quaternary Sabine . .	Hard. . Soft . .	Well at Lake Point on Red River.	788
2½	197	174	— 15	197	. . . .	. . . .	. . .do . .	Soft, alkaline.	Temperature, 66° F.; casing, 100 feet.	789
. . . .	200±	170±	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Poor . .	. . . . . .	790
3	210	167	[4]— 14	200-210	. . . .	20	Sabine . .	Hard. .	Casing, 150 feet. . .	791
3	215	167	— 10	. . . . . .	. . . .	20	. . .do . .	Soft . . .	Casing, 140 feet.	792
2½-1¼	250	230	. . . .	200-250	. . . .	. . . .	. . .do . .	. . do . .	1¼ inch screen from 200 to 25∙ feet; completed in 1890.	793
. . . .	300	. . . .	. . . .	105-111	. . . .	. . . .	. . . . . .	. . . . .	Screen placed 105-111 feet.	794
. . . .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	See No. 804.	
3-2	260	186.5	— 12	245-260	. . . .	Large.	Sabine . .	Soft . . .	Casing, 3 inches, 0-16∙ feet; 2 inches 160-220.	795
2½	225	187.5	— 8	213-225	. . . .	. . . .	. . .do . .	do . .	Temperature, 66° F; casing, 100 feet.	796
2½	240	193	— 4	30-125 230 240	. . . .	Large. . .do	Pleistocene Sabine . .	Hard. . Soft .	Grav l at 125 feet; Crescent place.	797
3	185	227	— 16		. . . .	. . . .	. . .do . .	Soft, fine	Casing, 100 feet.	798
1½-1½	371	182	— 12	219 225	. . . .	. . . .	. . .do . .	Soft . .	No water below 225 feet.	7?9
3 3	391 182	183	— 16	170-182	. . . .	16	. . .do . .	Soft, brackish	. . . .	800
. . .	425	175	. . . .	425	. . . .	Large.	. . . . . .	Hard, salty.	Abandoned.	801
3	750	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Dry hole, abandoned	802
3-2	290	205	[5]+0.4	152-158 252 270	1	50	Sabine . .	Soft . .	Completed in 1900.	803
. . .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	804

3 Lowers on pumping to—24 feet.
4 Depth to water in 1898 was 6 feet.
5 Sept. 20, 1902. In 1900 water would rise 2 feet.
6 Geol. Survey Louisiana, Rept. for 1899, 1900, pp. 179-181.

Wells and springs in

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	CADDO PARISH—continued.						
*805	Robson	16 N .	12 W .	18. . .	Captain Robson .	A. L. Pullin . . .	A. L. Pullin . . . .
*806	Shreveport (Market street and Cross Bayou).	. . . .	. . . .	. . . .	Shreveport Ice Co.	American Well Works Co.	. . . .
						. . . .	F. Collins, engineer.
*807	Shreveport (Louisiana avenue and Cross Bayou).	. . . .	. . . .	. . . .	Shreveport water works.	A. L. Pullin . . .	H. F. Juengst, C. E.
*808	Shreveport (Spring between Texas and Milam streets).	. . . .	. . . .	. . . .	Henry Rose . . .	Stoer & Backus. .	Stoer & Backus
809	Shreveport (Market and Cypress streets).	. . . .	. . . .	. . . .	Shreveport Street Railway.	. . . .	L. M. Levison . .
810	Shreveport (Edwards and Cypress streets).	. . . .	. . . .	. . . .	Shreveport Gas, Electric Light and Power Co.	. . . .	Engineer . . . .
811	Shreveport (Marshall and Crockett streets).	. . . .	. . . .	. . . .	Shreveport Athletic Association.	Stoer & Backus. .	Chas. Stoer. . . .
*812	Shreveport (Milam and Louisiana streets).	. . . .	. . . .	. . . .	The Inn	. . . do	. . . do . . . . .
813	. . . do	. . . .	. . . .	. . . .	Aloe Simpson . .	. . . do	. . . do . . . . .
814	Shreveport (Louisiana and Donovan streets).	. . . .	. . . .	. . . .	Andrew Currie . .	. . . .	. . . .
815	Shreveport (Louisiana and Howell streets).	. . . .	. . . .	. . . .	Queen City Laundry	Stoer & Backus. .	John Sewell, proprietor.
816	Shreveport (Louisiana and Lake streets).	. . . .	. . . .	. . . .	Star bottling works	. . . do	Chas. Stoer. . . .
*817	Shreveport (Commerce and Battle streets).	. . . .	. . . .	. . . .	City Ice Co.	. . . do	—Alexander, manager.
818	Shreveport (Texas and Tryon streets).	. . . .	. . . .	. . . .	Chas. Stoer. . . .	. . . do	Chas. Stoer. . . .
819	Shreveport (Texas street .	. . . .	. . . .	. . . .	C. C. McCloud . .	. . . do	. . . do . . . .
820	Shreveport (M. K. & T. and T. & P. crossing).	. . . .	. . . .	. . . .	Shreveport Ice Co.	A. L. Pullin . . .	A. L. Pullin . .
						Stoer & Backus. .	Chas. Stoer. . .
821	Shreveport Junction.	. . . .	. . . .	. . . .	Texas and Pacific Rwy.	American Well Works Co.	. . . . . .

*For additional data see "Descriptive notes," following this table.
[1]Depth also given, 165-175.
[2]Each well.
[3]Test November, 1899.

nthern Louisiana—Continued

ORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
4	225	155	—16	79–106 225	....	Large. ..do.	Pleistocene Sabine..	Hard, alkaline iron. Soft, magnesia.	Completed in 1898.	805
4	996	171	—20 +15	200± 961-996	....	....	...do.. Nacatoch.	Soft.. Brine.	With gas; temperature, 84° F.	806
5 4½ 4½	1250	171	—30	200±	....	[5]25	Sabine..	Soft..	Water used in making ice; temperature, 70° ± F.	806
6-4½	244	194	—43	218-228	....	370	...do..	..do..	City supply from filtered surface water.	807
4-2½	280	185	—18	......	....	20	...do..	..do..	Temperature, 66° F.	808
4	120	185	....	120	....	....	...do.	..do..	Good for boiler purposes.	809
4	350±	185	—40	......	....	....	...do..	Slightly hard.	....	810
6-4	338	182	—24	106 150 ?	...	30±	...do..	Alk'line soft.	Casing, 6-inch, 0 to 96 feet; 4-inch, 96 to 150 feet; screen, 20 feet	811
4-2½	324	190	....	99 109 148-163 ?	...	30	...do..	Soft..	Pumps sand if pumped hard.	812
4-2½	335	195	—32	93-105 148-163 ?	...	...	...do..	.....	Casing 4 inch, 0 to 83 ft.; 2½ inch, 83 to 157 ft.; used for laundry.	813
	Springs	....	....	......	50 ±	....	......	Soft..	Used largely for drinking water in Shreveport.	814
3	150±	177	—45	......	....	Large.	Sabine..	..do..	Used for laundry in 1898.	815
3-1½	137+	185	—30	117 ?	...	..do.	...do..	..do..	Casing and screen, 137 feet; temperature, 68° F.	816
6-4	150	182	....	140- 150	....	47	..do..	..do..	Water scales badly.	817
6-4	180	182	—18	......	....	9	..do..	..do..	Water scales badly.	817
6 4	29)	182	....	......	....	7	..do..	..do..	Water scales badly.	817
2½	350±	215	—20	......	....	....	......	.....	....	818
2½	[illegible]	....	....	......	....	....	......	.....	....	819
6-4½	237	230	....	140–146 213-225	...	+30	Sabine..	Soft..	Completed June, 1899; temperature, 68° F.	820
6-4½	338	230	—45	140-150 ?	..	5+30	...do..	Iron, soft[6].	Completed June, 1901; lignite at 240 feet.	820
7	561	230	—50	80-100 250 280	...	60	...do..	Soft	No water below 280 ft.	821

[4]With air lift; driller reports 24 gallons each with deep-well pump.
[5]Estimated by engineer 75 gallons.
[6]Slight smell of hydrogen sulphide.

Wells and spring

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	CADDO PARISH continued.						
822	. . . do.	. . . .	. . .	. . . .	Stave factory . . .	. . . .	Chas. Stoer. . . .
823	Shreveport (High House addition)	. . . .	. . . .	. . . .	R. E. Bell	Stoer & Backus. .	. . . do . . . .
824	Shreveport .	. . . .	. . . .	. . . .	T. C. Backus . . .	. . . do	. . do . . . .
825	Shreveport (Olive street).	. . . .	. . . .	. . . .	Claiborne Foster .	Chas. Stoer. . . . A. L. Pullin . . .	. . do . . . . A. L. Pullin.
826	. . . do	. . . .	. . . .	. . . .	J. M. Foster . . .	. . do . . . . . . Chas. Stoer.	. . . do . . . Chas. Stoer. .
827	Shreveport (9-Mile House).	. . . .	. . . .	. . . .	S. B. Nichols. . .	Richter & Pullin .	. . . do . .
828	Shreveport, 2½ miles southeast of, on Grigsbys Island.	17N .	13W .	. . . .	Ardis & Co. . . .	. . . .	U. H. Brown, etc.
*829	Shreveport, 3 miles southeast of, on Shreves Island.	17N .	13W .	. . . .	Aug. Mayer . . .	. . . .	Aug. Mayer . .
830	Shreveport, 4 miles southeast of, on Harts Island.	17N .	13W .	. . . .	Andrew Querbes .	. . . .	Chas. Stoer. .
831	Shreveport, 8 miles southeast of, on Dogwood Place.	17N .	13W .	. . . .	R. K. Colquitt . .	Stoer & Backus. .	. . . do . . . . .
*832	Shreveport, 10 miles southeast of, on Bayou Pierre.	. . . .	. . . .	. . . .	A. H. Leonard . .	. . . do	Stoer & Backus.
*834	Surrey.	20N .	16W .	1 . . .	. . . .	. . . .	A. C. Veatch. .
*835	Uni	20N .	14W .	. . . .	Uni Plantation . .	A. L. Pullin . . .	A. L. Pullin.
836	Uni, 1 mile west of	21N	14W .	8 . . .	W. S. Taylor. . .	. . . do	. . do . . . . .
	CALDWELL PARISH						
*837	Brankston	14N	3E .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marsh
*838	Clarks.	12N	3E .	. . . .	Clark Spur Lumber Co	Oscar Shanks. . .	Oscar Shanks .
839	. do	12N	3E .	. . . .	. . . do	. . . do	. . . do . . . .
*840	. do	12N .	3E .	. . . .	. . do	. . . do	. . . do . . .
*841	Columbia	13N	3E .	17. . .	Town of Columbia	Oscar Shanks. . .	County clerk . .
*842	Columbia, 2 miles below . .	13N	3E .	. . . .	U. S. Eng test boring	. . . .	M. H. Marsh.
*843	Columbia . .	. . . .	. . . .	. . . .	. . . do	. . . .	. . do . . . .
*844	Col'bia, 1 mile above	. . . .	. . . .	. . . .	. . . do	. . . .	. do . . . .
*845	Columbia, 2 miles above.	. . .	. . . .	. . . .	. . . do	. . . .	. . . do . . . .
*846	Columbia, 3 miles above.	. . . .	. . . .	. . . .	. . do	. . . .	. . . .
*847	Ouachita River (Call Landing[1].	. . . .	. . . .	. . . .	. . . do	. . . .	. . . .

*For additional data see "Descriptive notes," following this table.
[1]Owner reports 15 feet.

orthern Louisiana—Continued

ORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (--) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
4 2½	180	230	—60	......	....	....	...do ..	.....	....	822
2½-1½	225	....	....	1 0-123 140-144 ?	...	....	...do ..	Soft ..	Casing, 158 ft.; completed September, 1901.	823
2½-1½	103+	....	....	103	....	....	...do ..	..do ..	....	824
2½	160	....	....	......	....	....	...do ..	..do ..	Casing, 100 feet.	825
2½	245	240±	....	......	....	....	...do ..	..do ..	Completed in 1890 .	
2¼	215	230±	....	......	....	....	...do ..	..do ..	...do	826
2½	180	....	....	......	....	....	...do ..	..do ..	Casing, 80 feet . . .	
2½	197	....	....	......	....	....	......	..do ..	Completed in 1897 .	827
2½	210	176	—18	......	....	+5	Sabine ..	..do ..	Does not scale boilers; temperature, 67.5° F.	828
2½	201	172	—15	100 200	....	 10	Quaternary. Sabine ..	Alk'line hard. Soft ..	Completed in 1893 .	829
2¼-1½	197	170	—20	......	....	....	...do ..	..do ..	....	830
2½ 1½	288	167	1—8	......	....	Large.	...do ..	..do ...	Casing, 110 feet. . .	831
2½-1½	205	....	—18	......	....	..do .	...do ..	..do ..	At gin	832
....	55	....	....	......	....	....	Quaternary.	Hard, sulphur	....	834
...	650	185	....	......	....	None.	......	.....	No water in sand between 190 and 195 ft.	835
....	370	....	....	......	....	..do .	......	.....	Same sections as Uni well.	836
....	51 50 50	27 15 27	...	......	....	....	......	.....	....	837
....	208	150±	—70	135-145	....	68	Cockfield.	Soft ..	Completed January, 1, 1903.	838
....	300	150±	—80	252-300	....	50	Cockfield?	Iron ..	Completed August, 1901.	839
....	180	150±	—80	110-150	....	30	...do ..	..do .	Bad for boilers and drinking. Completed in 1902.	840
4-2	503	65	+35	423-503	20	....	Sabine ..	Soft, magnesia.	Completed August, 1903.	841
....	43	15	....	......	....	....	......	.....	....	842
....	52	18.5	....	......	....	....	......	.....	....	843
....	220	20	....	......	....	....	......	.....	....	844
....	48	28	....	......	....	....	......	.....	....	845
....	52	24	....	......	....	....	......	.....	....	846
....	50 50	14 16	...	......	....	....	......	.....	....	847

[2]Geol. Survey Louisiana, Rept. for 1899, [1900], p. 190.
[3]Rept. Chief of Eng. for 1902, pt. 2, 1902, pp. 1560-1563.

Wells and springs in

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	CALDWELL PARISH—continued						
*848	Ouachita River (Lower Breston place.)	....	....	....	...do......	....	...do......
*849	Ouachita River (Upper Breston place)	....	....	....	...do......	....	...do......
*850	Ouachita River (Smithland.)	....	....	....	...do......	....	...do......
	CATAHOULA PARISH						
*851	Black River (New Hope place.)	6N..	7E .	....	Test boring ...	....	M. H. Marshall[1].
*852	Black River (Star View place.)	6N..	7E .	....	...do......	....	...do......
*853	Black River (Jones Bayou).	7N..	6E .	....	...do......	....	...do......
*854	Catahoula Lake ..	....	....	....	....	....	....
*855	Leland	....	....	....	Catahoula Oil and Development Co.	....	S. McDowell, president.
*856	Olla	11N..	2E .	....	St. Louis, Iron Mountain and Southern Rwy.	....	E. Fisher, chief engineer of bridges and buildings.
857	Olla, 1 mile south of	11N..	2E .	....	Smith & Adams Lumber Co.	....	Smith & Adams Lumber Co.
*859	Ouachita River (Catahoula Shoals).	....	....	....	Test boring....	....	M. H. Marshall[1]..
860	Tullos	10N..	1E .	....	St. Louis, Iron Mountain and Southern Rwy.	....	Postmaster....
861	Tullos, northeast of.	....	....	....	....	....	A. R. Kilpatrick[1].
*862	White Sulphur Springs.	7N..	2E .	....	....	....	S. H. Lockett[4]...
	CLAIBORNE PARISH						
862 A	Haynesville	....	....	....	Hampton Stave Co.	Chas. Halloway .	Hampton Stave Co.
*863	Lisbon, 6 miles east of.	21N..	4W .	15	....	....	Dr. O. Lerch[5]
864	State line	23N..	8W .	....	J. F. Deloach & Bro.	Stoer & Backus..	Chas. Stoer....
	CONCORDIA PARISH						
....	Black River	....	....	....	....	....	....
865	Black River station.	7N..	6E .	....	Natchez, Red River and Texas R. R.	....	A. A. Gardner, vice president.
866	Ferriday	....	....	....	Texas and Pacific Rwy.	....	B. S. Wathen, chief engineer.
*867	Fish Pond.....	....	....	....	.. do.....	....	C. H. Chamberlain, division engineer
868	Helena	....	....	....	New Orleans and N'eastern R. R.	....	S. McDowell..
869	Vidalia	7N..	10E .	....	Natchez, Red River and Texas R. R.	....	A. A. Gardner, vice president.
870	...do......	7N..	10E .	....	Concordia Oil Co.	....	S. McDowell..

*For additional data see "Descriptive notes," following this table.
[1]Rept. Chief of Eng. for 1902, pt. 2, 1902, pp. 1560-1563.
[2]See "Descriptive notes."
[3]DeBow's Review, vol. 12, 1852, pp. 268-269.

[N]orthern Louisiana—Continued

[N]ORTHERN)—Continued.

[D]iameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above ( ) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
[I]nches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
...	47	13	....	......	....	....	......	.....	....	848
...	52 52	17 18	....	......	....	....	......	.....	....	849
...	47	19	....	......	....	....	......	.....	....	850
...	39 41	5 2	....	......	....	....	......	.....	....	851
...	50	8	....	......	....	....	......	.....	....	852
...	50	6	....	......	....	....	......	.....	....	853
...	Springs	....	....	......	....	....	......	Salty. .	Numerous salt sp'gs.	854
	1,550	....	Flows.	([5])	10	....	Cockfield.	.....	Salt water with gas; temperature 86.5° F.	855
...	374	....	....	......	....	Small	......	.....	Abandoned.	856
...	297	150±	—130	......	....	Large	Cockfield.	Sulphur, iron.	Not used.	857
...	197	11	Flows.	158–197	60	....	Catahoula	.....	....	859
...	400±	106	....	......	....	....	Cockfield.	Salty. .	....	860
....	Springs	....	....	......	....	....	......	Brine .	Bayou Castor salt springs.	861
....	. do . .	....	....	......	....	....	Catahoula	Sulphur.	....	862
4-3	600	350+	—20	......	....	Large .	Sabine . .	Soft . .	Completed in 1904 .	862 A
....	Spring.	....	....	......	....	....	......	.....	....	863
3-1½	285	....	— 65	205–285	....	....	Sabine . .	Good, soft	Completed in 1900; casing 200 feet.	864
....	....	....	....	......	....	....	......	.....	See under Catahoula Parish.	....
5	70	....	....	......	....	....	Quaternary	.....	....	865
....	950	60	Flows.	950	Small.	Large .	Catahoula	Brine .	Alluvial d'p's, 0-80; yellow clay, 80–950.	866
4	145	....	—10	105–145	....	140	Quaternary	.....	Used for locomotives	867
....	340?	60	Flows.	......	....	....	......	Brine .	Probably refers to Ferriday well.	868
5	70	63	—40	......	....	15	Quaternary	.....	....	869
....	300±	63	...	......	....	....	Catahoula	Fresh .	....	870

[4]Ann. Rept. Louisiana State Univ. for 1869, 1870, p. 57.

[5]Preliminary report on the wells of Louisiana south of the Vicksburg, Shreveport and Pacific Railway; Geol. and Agr. [o]f Louisiana, pt. 2, 1893, p. 118.

Wells and springs

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	DE SOTO PARISH						
*871	Frierson	15N.	13W	....	R. G. Hedrick	....	Foreman
871 A	Grand Cane, 3½ mi., from.	....	....	....	....	....	A. C. Peale[1]
	EAST CARROLL PARISH						
*872	Hays Landing	20N.	13E	....	Test boring	....	E. W. Hilgard
*873	Lake Providence	21N.	13E	....	do	....	do
874	do	21N.	13E	....	Town of Providence	L. B. Hart Well Co.	F. J. Powell
*875	do	21N.	13E	....	....	....	G. D. Harris
	FRANKLIN PARISH						
876	Wisner	12N.	8E	....	St. Louis, Iron Mountain and Southern Rwy.	C. H. Winters	C. H. Winters
	GRANT PARISH						
*877	Colfax	6N.	3W	7	Town of Colfax	L. B. Hart Well Co.	L. B. Hart
878	Fairmount	5N.	3W	....	General	....	Postmaster
879	Georgetown	9N.	1E	....	do	....	do
*880	Pollock	6N.	1E	....	Big Creek Lumber Co.	....	......
*881	Rochelle	9N.	1E	....	Louisiana Lumber Co. (Ltd.)	Oscar Shanks	Oscar Shanks
*882	Sandspur (Antonia station.)	7N.	1E	....	St. Louis, Iron Mountain and Southern Rwy	do	do
*883	Stay	6N.	1W	...	S. Hopper Mill Co.	do	do
	JACKSON PARISH						
*884	Ansley	16N.	3W	5	Davis Bros	L. B. Clifford Well Co.	L. B. Clifford
*885	Hodge	16N.	3W	19	Huie-Hodge Lumber Co	do	do
*886	Jonesboro	15N.	3W	31	Southern Arkansas Lumber Co.	L. B. Clifford Well Co.	G. S. Smith
*887	Wyatt	....	....	....	Wyatt Lumber Co.	do	L. B. Clifford
	LINCOLN PARISH						
*888	Chautauqua Station.	....	....	....	La. Chautauqua.	....	Dr. O. Lerch
889	Dubach	20N.	3W	26	Fred B. Dubach Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford
*890	Ruston	18N.	3W	....	Ruston Waterworks	do	do

*For additional data see "Descriptive notes," following this table.
[1]Bull. U. S. Geol. Survey No. 32, 1886, p. 124.
[2]Ann. Rept. Miss. River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884, pp. 494-495.
[3]Geol. Survey Louisiana, Rept. of 1902, pp. 231-232.

thern Louisiana—Continued.

RTHERN)—Continued.

me-r of ll.	Depth of well.	Approximate elevation of surface.	Heigh of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
hes	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
-4	1,500	198	Flows.	241-281 998-1,275	 10	....	Sabine.. Nacatoch?	..... Salty..	Not tested..... Salt water with gas; temperature 70°F.	871
..	....	....	....	......	+60	....	Sabine..	.....	De Soto Mineral Springs, local resort	871 A
..	181	100±	....	......	....	....	......	.....	Test boring of Mississippi River Commission.	872
..	248	105	....	......	....	....	......	.....	....	873
6	271	105	—22	......	....	80	Eocene..	Good	....	874
..	112	105	....	......	....	....	Quaternary	.....	Water excessively ferruginous.	875
..	100	75	—30	......	....	+50	Quaternary	.....	....	876
2½	1,128	96	—15 +65	70-130 1,103	 440	Large.	Quaternary Cockfield.	..... Salty..	Gas at 660 and 1,100 ft; 2 ounces of salt per gallon.	877
..	25	94	....	......	....	....	Quaternary	Hard.	....	878
..	35	76	....	......	....	....	.....	Soft..	Below 35 feet water is salty.	879
-4	910	88	5+16	255	2	....	Catahoula	..do..	Used for drinking purposes.	880
..	565	80	+5	555-565	1	75	Cockfield.	Salty..	Abandoned...	881
6	75	189	—45	60-75	....	124	Lafayette?	Soft..	Group of three wells	882
6	78	...	—45	60-78	....	100	.....	..do..	Water in gravel...	883
5	245	190	—33	190-245	....	100	Sabine..	Soft..	Pumping 100 gallons per minute water lowers to 80 feet.	884
4	300	205	—36	292-300	....	50	..do..	..do..	Casing 300 feet; completed in 1901.	885
5	545	200	—34	500-545	....	40	..do..	..do..	Well at planer, completed in 1901.	886
4	538	200	—34	490-538	....	34	..do..	..do..	Well at sawmill, completed in 1902.	
4	302	200±	... —52	242-252 272-302	..	55	..do..	..do..	....	887
..	Spring.	....	....	......	....	....	......	Iron..	....	888
5	179	135+	+6	173-179	....	Large.	Sabine..	Soft..	Many fossil shells above water horizon	889
3-6	425	288	7—120	120-126 373-425	....	 68	Claiborne (lower). Sabine..	..... Soft..	Will lower 40 ft. when pumping 100,000 gallons per day.	890

[4] In 1900; in 1902 flow reported 20 gallons.
[5] In 1896; in 1902 would rise only 5 feet.
[6] Geology and Agriculture of Louisiana, pt. 1, 1893, pp. 46-47.
[7] Chief engineer gives depth in 1902 as 137 feet.

Wells and spring
LOUIS...

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority
	LINCOLN PARISH—continued						
891	Ruston	18N. .	3W	. . . .	Ruston Compress Co.	L.B.Clifford Well Co.	L. B. Cliff...
	MADISON PARISH						
892	Barnes	16N. .	13E .	. . . .	Vicksburg, Shreveport and Pacific Rwy.	. . . .	R. B. Co... tendent ... sion
*893	Delta	16N. .	15E .	. . . .	. . . do	. . . .	. . . do . . .
*894	Mound	16N.	14E .	. . . .	. . . do	. . . .	F. L. Ma...
	MOREHOUSE PARISH						
*895	. . . .	. . . .	. . . .	. . . .	General	. . . .	A. E. Wa... ish surve...
*896	Bastrop	21N.	5E .	. . . .	Court-house . . .	. . . .	W. A. H...
*897	Collinston	20N. .	6E .	. . . .	St. Louis, Iron Mountain and Southern Rwy.	C. H. Winters . .	C. H. Win...
*898	Mer Rouge . . .	21N. .	7E .	. . . .	. . . do	Oscar Shanks. . .	Oscar Sha...
899	Oak Ridge	19N. .	7E .	. . . .	. . . do	C. H. Winters . .	C. H. Wi...
	NATCHITOCHES PARISH						
900	Allen	. . . .	. . . .	. . .	General	. . . .	D. A. B...
*901	Boleyn	9N. .	10W .	19	Petty & Brown Lumber Co.	. . . .	D. G. Fe...
902	Campti, 2 miles northeast of.	. . . .	. . . .	. . . .	Louisiana Railway and Navigation Co.	. . . .	Louisiana ... and Nav...
903	Derry	. . . .	. . . .	. . . .	General	. . . .	Postmaste...
*904	Goldonna[3]	12N. .	5W .	21	Louisiana and Arkansas Rwy.	H. H. Jones . . .	H. H. Jo...
905	Grappes Bluff . . .	11N. .	8W .	. . . .	Sawmill	A. L. Pullin . .	A. L. P...
*906	Luella.	9N. .	6W .	. . . .	J. W. Cockerham, Jr.	. . . .	J. W. Coc...
907	. . . do.	9N. .	6W .	. . . .	. . . do	. . . .	. do .
*908	Montrose	7N. .	6W .	. . . .	Montrose Lumber Co.	. . . .	J. C. R...
909	Natchitoches. . . .	9N. .	7W .	. . . .	City waterworks .	Clifford Well Co .	Judge C. ... super...
*910	. . . do.	9N. .	7W .	. . . .	do	. . . .	. . do .
*911	. . . do.	9N. .	7W .	. . . .	Natchitoches Normal School.	Andrews Well Co.	President ...
912	Natchitoches, 1 mi west of.	9N. .	7W .	. . . .	Fourth of July Spring	. . . .	G. D. Ha...
*913	Natchitoches, 1½ miles northwest of.	9N. .	7W .	. . . .	Iron Springs . . .	. . . .	. . . do .

*For additional data, see "Descriptive notes," following this table.
1Varies with height of river.
2Harris. G. D., Geol. Survey Louisiana, Rept. of 1902, pp. 231.

rthern Louisiana—Continued

ORTHERN)—Continued

iameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
ches.	*Feet*	*Feet*	*Feet*	*Feet*	*Galls.*	*Galls.*				
4	449	301	—140	. . . . . .	. . .	68	Sabine . .	Soft . .	Supplies compress and ice factory.	891
. . .	72	81	([1])	28–72	. . . .	. . . .	Quaternary	. . . . .	Used for locomotives	892
. . .	1,200±	87	[1]—38	12–50 100–135	. . . .	. . . .	. . . . . .	. . . . .	No water below 135 feet.	893
6	135	83	[1]—30	. . . . .	. . . .	. . . .	Quaternary	. . . . .	Used for locomotives	894
. . .	25-60	. . . .	. . . .	. . . . . .	. . . .	. . . .	Quaternary	Slightly hard.	. . . .	895
36±	153	[2]113.4	[2]—67.1	67–153	. . . .	. . . .	. . .do . .	. . . . .	. . . .	896
6	81	79	— 8	64–81	. . . .	140+	. . .do . .	. . . . .	Good soft water; excelent for locomotives	897
6	79	93	— 7	79–89	. . . .	70	. . .do . .	Iron . .	Completed in 1898 .	898
. . .	40	([1])	. . . .	24–40	. . . .	. . . .	. . .do . .	. . . . .	. . . .	899
. .	Springs	. . . .	. . . .	. . . . . .	. . . .	. . . .	Sabine . .	. . . . .	Many chalybeate springs	900
1	412	250±	+20	412	. . . .	. . . .	. . .do . .	Good .	. . . .	901
. .	Spring.	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . do . .	Supplies railroad tank by pipe line.	902
. .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	No wells. Cisterns used exclusively.	903
. .	475+	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Test well.	904
4	155	145	—25	. . . . . .	. . . .	. . . .	Quaternary	. . . . .	Water in coarse sand and gravel, 30-foot screen.	905
4	707	111	—20 Flows . do .	36–300? 640 700–707	. . . .	. . . .	. . .do? . Sabine . . . . .do . .	Iron . . Salty . . . do . .	. . . .	906
4 4 4	36 86 106	110	—20	. . . . . .	. . . .	10+	Quaternary	Iron . .	. . . .	907
6	496	100	. . . .	80–180	. . . .	Large.	. . .do . .	Poor . .	No water below 180 ft.	908
4	457	130	— 4	200–220 457	. . . .	. . . .	Sabine . . . . .do . .	Salty . Brine .	Salt water with gas .	909
50 1½	19-64	. . . .	— 5	. . . . . .	. . . .	200	. . . . . .	Good, soft .	. . . .	910
2½	726	130	— 12 . . . . [4]—0.5	35–38 96–108 710–726	. . . .	25	Claiborne? Sabine . . . . .do . .	Brine . Fresh Brine .	Small amount of gas at 710 feet.	911
. . .	Springs	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . .do . .	. . . . .	Local resort	912
. . .	. . .do .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . .do . .	Iron . .	. . . .	913

[3]See No. 994, Drakes Salt Works, Winn Parish.
[4]Flowed for a short time after completion.
[5]Geol. Survey Louisiana, Rept. of 1902, pp. 147–148.

Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
NATCHITOCHES PARISH—continued						
Natchitoches, 2 mil's northwest of.	9N . .	7W .	. . . .	Breazeale Springs	. . . .	G. D. Harri
Natchitoches, 2 mil's north of.	9N .	7W .	. . . .	Sulphur Spring . .	. . . .	. . . .
Sans Souci	11N . .	6W .	22	. . . .	. . . .	. . . .
Weaver Spur . . .	. . . .	. . . .	. . . .	Weaver Bros . . .	Stoer & Backus . .	Chas. Stoer .
OUACHITA PARISH						
Bosco	. . . .	. . .	. . . .	U.S. Eng. test boring.	. . . .	M. H. Marsh
Cheniere, 3 miles southeast of.	17N .	3E .	. . . .	Louisiana Oil Co .	. . . .	. . . .
Logtown	. . . .	. . . .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marsh
Monroe	. . . .	. . . .	. . . .	Consolidated Ice Co.	Will A. Strong . .	Will A. Strong
. . . do.	. . . .	. . . .	. . . .	. . . do	. . . .	Consolidated .
. . . do.	. . . .	. . . .	. . . .	Monroe Waterw'ks and Light Co.	Will A. Strong . .	Will A. Strong
. . do.	. . . .	. . . .	. . . .	Planters' Oil Co .	. . . .	. . . .
Monroe, ¾ mile south of.	. . . .	. . . .	. . . .	Ouachita cotton mills.	. . . .	Guy P. Stubbs
Monroe, ½ to 1½ miles north of.	. . . .	. . . .	. . . .	. . . .	. . . .	G. D. Harris
Monroe, 6 miles north of.	. . . .	. . . .	. . . .	Stubbs's place . .	. . . .	M. M. Ma[illegible]
Monroe	. . . .	. . . .	. . . .	U.S. Eng. test borings.	. . . .	M. H. Marsh
Rock Row Shoals (Ouachita River.)	19N . .	3E .	. . . .	. . . .	. . . .	. . . .
POINTE COUPEE PARISH						
. . . .	. . . .	. . . .	. . . .	General	. . . .	E. G. Beaker
Batchelor	. . . .	. . . .	. . . .	Texas and Pacific Rwy.	. . . .	B. S. Walker engineer
New Roads	. . . .	. . . .	. . . .	. . . do	. . . .	. . . do . . .
RAPIDES PARISH						
Alexandria (city hall)	4N . .	1W .	. . . .	Corporation of Alexandria.	Andrews Well Co.	(4)
Alexandria (waterworks).	4N . .	1W .	. . . .	. . . do	. . do	(4)

*For additional data see "Descriptive notes," following this table.
[1]Ann. Rept. Chief of Eng. for 1902, pp. 1564–1566.
[2]Geol. Survey Louisiana, Rept of 1902, p. 211.
[3]Pump repairer, St. Louis, Iron Mountain and Southern Rwy.

thern Louisiana—Continued

)RTHERN)—Continued

ame- r of ell.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (--) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
ches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
...	Springs	...	...	...	...	...	Sabine..	...	...	914
...	..do	...	...	...	...	...	...do..	Sulphureted.	...	915
...	..do	...	...	...	...	...	...do..	Iron..	Local resort....	916
4-2½	308	...	−17	188	...	...	Cockfield.	Good.	Casing, 188 feet...	917
...	44 32	25 16	...	...	...	...	...	...	...	918
...	515	85	Flows.	265-275 465-515	Small.	...	Sabine..	...	...	919
...	50 50	15 17	...	...	...	...	...	...	...	920
5-3½	485	75	+40	20 65 280-485	 50	 50	Quaternary ..do.. Sabine..	Alkaline ..do.. Soft..	Drilled in 1891...	921
5-3½	360	75	+40	280-360	50	50	...do..	..do..	Drilled in 1892; casing 80 feet.	921
7-3½	400	75	Flows.	250-400	20	50	...do..	Very soft	Drilled in 1901..	922
5-3½	385	80	.do..	320-385	...	...	...do..	Soft..	Temperature 71° F.; completed in 1892.	923
4	400 ±	82	.do..	...	30	...	...do..	..do..	...	924
5-3½	375	85	.do..	...	3	...	...do..	do..	Used for factory and drinking.	925
...	400 ±	...	.do..	...	...	...	...do..	...	Three wells.....	926
4	260	...	.do..	...	...	...	...do..	...	Completed February, 1903; second well on this farm.	927
...	51 50 44	38 44 28	...	...	...	...	...	...	...	928
...	157 63	42 39	...	...	...	...	...	...	...	929
2-8	145-165	...	...	...	...	Large.	Quaternary	...	Palatable for drinking in some cases; used for machinery on sugar and cotton plantation.	930
...	170	...	...	...	...	...	...do..	Good.	All alluvial; water in sand and gravel.	931
...	150	...	...	...	...	...	...do..	..do..	Water in sand and gravel.	932
1½	473	78	[5]+10 [6]−60	...	10 ±	...	Catahoula	Soft..	...	933
4-2½	560	77	[5]+12 [6]−138	540-560	50 ±	118	...do..	..do..	Well No. 1...	934

[4]See "Descriptive notes."
[5]In 1898.
[6]August 6, 1902.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	RAPIDES PARISH continued.						
*935	Alexandria (Waterworks).	4N. .	1W .	. . . .	Corporation of Alexandria.	Andrews Well Co.	(1)
*936	Alexandria (corner Fourth and St. James streets).	4N. .	1W .	. . . .	. . . do	. . . do	(1)
*937	Alexandria (round house).	4N. .	1W .	. . . .	St. Louis. Iron Mountain and Southern Rwy.	Hart Well Co . .	L. B. Hart . .
*938	Alexandria (Sixth and Monroe sts).	4N. .	1W .	. . . .	Alexandria Ice and Storage Co.	Andrews Well Co.	Jas. Drouant[4]
*939	. . . do.	4N. .	1W .	. . . .	. . do	Hart Well Co . .	G. D. Harris
*940	Alexandria	4N. .	1W .	. . . .	Sonia Cotton Oil Co.	. . . .	Ira W. Sylvester
*941	Ball	5N. .	1E .	. . . .	Ball Sawmill Co.	Shanks & Smith .	Oscar Shanks . .
942	Boyce	5N. .	3W .	. . . .	Texas and Pacific Rwy.	Hart Well Co . .	L. B. Hart . .
*943	. . do.	5N. .	3W .	. . . .	. . . do	. . do	. . . do . . .
*944	. . . do.	5N. .	3W .	. . . .	Boyce Ice Manufacturing Co.	. . . .	D. J. Heidrick
945	. . . do.	5N. .	3W .	. . . .	M. Grillette . .	. . . .	. . . do . . . .
946	. . . do.	5N.	3W .	. . . .	Boyce Cotton Oil and Manufacturing Co.	. . . .	H. P. Haynes, president.
*947	Lamothe	. . . .	. . . .	. . . .	L. C. Sanford . .	. . . .	L. C. Sanford .
948	Lecompte.	1N. .	1E .	. . . .	Corporation of Lecompte.	. . . .	Ira W. Sylvester, consulting engineer
949	Loyd	1N. .	1E .	. . . .	Postmaster . . .	. . . .	General . . .
*950	Pineville	4N. .	1W .	. . . .	Pineville Development Co.	. . . .	F. S. Hoyt, president
*951	do.	4N. .	1W .	. . . .	State Insane Asylum.	Oscar Shanks. . .	Oscar Shanks.
*952	Rapides	5N. .	1W .	. . . .	C. A. Morrow . .	. . . .	C. A. Morrow
*953	do.	4N. .	2W .	. . . .	. . . do	. . . .	. . . do . . . .
954	Richland	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . .
955	Springhill	4N. .	4W .	1, 2	J. A. Bentley Lumber Co.	. . . .	J. A. Bentley . .
*956	Zimmerman	5N. .	3W .	. . . .	. . . do	. . . .	. . . do . . . .

*For additional data see "Descriptive. notes," following this table.
[1]See "Descriptive notes."
[2]In 1898.
[3]August 6, 1902.
[4]Foreman for Andrews Well Co.

orthern Louisiana—Continued

ORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
10-4	760	77	[2]+12 [3]—110	540 620 760	70±	121	Catahoula	Soft . .	Well No. 2.	935
2	606	76	[2]Flow [3]—49	. . . .	. . . .	. . . .	. . .do . .	. . do . .	. . . .	936
6-4	858	75	. . . .	850	. . . .	. . . .	. . . . . .	. . . . .	Abandoned.	937
8	580	77	—60	480 580	. . . .	60	Catahoula	. . . .	Abandoned.	938
8	621+	77	. . . .	. . . . . .	. . . .	. . . .	. . . . . .			
. . .	927	77	Flows.	853-927	125	. . . .	Catahoula	Soft .	. . . .	939
. . .	110	. . . .	. . . .	. . . . . .	. . . .	Large.	Quaternary.	Hard. .	. . . .	940
. . .	365[5]	145	—60	310-365	. . . .	. . . .	. . . . . .	. . . . .	Drilled in 1899 . . .	941
7	300	88	+15	300	. . . .	100	Catahoula	Soft . .	Temperature, 60° F.; drilled in 1898.	942
6-4	810	88	+18	300 802	. . . .	. . . .	. . .do . . Catahoula?	. . do . . Brackish.	Drilled in 1898 . . .	943
8	302	85	[6] +34	292-302	. . . .	30+	Catahoula	Soft . .	Drilled in 1900; used for ice manufacture, casing 200 feet.	944
2	280	88	Flows.	. . . . . .	. . . .	. . . .	. . .do . .	. . do . .	. . . .	945
3½	279	. . . .	+7	. . . . . .	[7]30 [8]4	. . .	. . .do . .	. . do . .	Used for drinking only; completed in 1839.	946
2	105	90	—8 —18	95-105	. . . .	Large.	Quaternary	Hard. .	. . . .	947
6	125	75	. . . .	. . . . . .	. . . .	100+	. . . do . .	. . do . .	Completed in 1902; pronounced an excellent water.	948
. . .	. .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Many large springs.	949
. . .	720 100 230+	. . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Test wells for oil . .	950
. . .	1,020	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	951
2	96-106	85	—20	94-104	. . . .	Large.	Quaternary	Slightly hard.	Four wells completed in 1900.	952
2	323	85	—20 —5 Flows (?)	96 108 280 320?	. . . .	. .do	.do . . Catahoula . . .do	. . do . . Soft . . . . do	. . . .	953
. . .	20-30	. . . .	. . . .	. . . . . .	. . . .	. . . .	Quaternary	Hard, alkaline.	. . . .	954
. . .	Spring.	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Soft . .	Supplies watering tank of Zimmerman, Leesville and Southern R. R.	955
4	175	94	9+25	175	[9]20 [10]2	. . . .	Catahoula	. . do . .	Temperature, August, 1902, 58° F.; used for drinking only.	956

[5]Water-Sup. and Irr. Paper No. 101, U. S. Geol. Survey, 1904, p. 20.
[6]Pressure stated to be 15 pounds when first drilled; lowers on pumping to —40 feet; casing 200 feet long.
[7]In 1899.
[8]August 12, 1902.
[9]In 1897.
[10]August, 1902.

Wells and springs
LOUISIANA

No.	Location	Township.	Range.	Section.	Owner.	Driller.	Authority.
	RED RIVER PARISH						
957	Coushatta	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . .
958	Coushatta, 10 miles east of.	12N. .	8W .	22	. . . .	. . . .	J. W. Martin . . .
959	Coushatta	. . . .	. . . .	. . . .	——Armstead . . .	Chas. Stoer. . . .	Chas. Stoer. .
*960	Lake End	11N. .	9W .	. . . .	Atkins Bros . . .	Stoer & Backus. .	Chas. Stoer. .
961	Wilson	14N. .	9W .	10	. . . .	. . . .	J. W. Martin
	RICHLAND PARISH						
962	Delhi	17N. .	9E .	. . . .	Cotton gin	. . . .	Mrs. A. K. Harris
963	Holly Ridge. . . .	17N. .	8E .	. . . .	Vicksburg, Shreveport, and Pacific Rwy.	. . . .	R. B Coxe, superintendent water division.
	SABINE PARISH						
964	East Pendleton . .	6N. .	14W .	2	Salt works	. . . .	A C. Veatch . .
965	. . . do.	6N. .	13W .	33	do	. . . .	. . . do . . .
*966	Loring	7N. .	12W .	9	Bowman-Hicks Lumber Co.	L.B. Clifford Well Co.	W. A. Shields, superintendent.
967	Many	7N. .	11W .	27	J. T. Sirmon . . .	. . . .	Dan Vandegaer, parish surveyor
968	Myricks Ferry . . .	9N. .	14W .	. . . .	. . . .	. . . .	E. W. Hilgard[4]
*969	Negreet	5N. .	12W .	5	D. M. Foster . .	D. M. Foster. . .	D. M. Foster.
970	Negreet Salt Works	5N. .	13W .	24	. . . .	. . . .	A. C. Veatch[2]
*971	Noble	8N. .	13W .	. . . .	Trigg Lumber Co.	L. B. Clifford Well Co .	L. B. Clifford
*972	Pleasant Hill . . .	9N. .	12 W .	2	John Ferrell . . .	. . . .	Dr. O. Lerch[3]
973	Plymouth	7N. .	12W .	8	Bowman-Hicks Lumber Co.	L. B. Clifford Well Co.	G. S. Smith[1]
*974	Zwolle.	8N. .	13W .	36	H. J. Allen Lumber Co.	. . . .	— Coxe, superintendent.
	ST. LANDRY PARISH						
*975	Melville, 12 miles south of.	6S . .	7E .	. . . .	Latannier Oil Co.	Oscar Shanks. . .	Oscar Shanks. .
	TENSAS PARISH						
976	Buck Ridge	. . . .	. . . .	. . . .	——Kelley	. . . .	F. L. Maxwell
977	St. Joseph	. . . .	. . . .	. . . .	General	. . . .	A. Blanche. .
	UNION PARISH						
*978	Ouachita River (Loch Lomond).	20N .	3E .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marshall
979	Randolph	23N. .	3W .	. . . .	Summit Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford
	VERNON PARISH						
980	Hawthorne	3N. .	9W .	29	Lumber company.	. . . .	. . . .
981	Pickering	. . . .	. . . .	. . . .	do	. . . .	—Pickering .

*For additional data see "Descriptive notes," following this table.
[1] Also reported 300 feet.
[2] Geol. Survey Louisiana, Rept. of 1992, p. 30.
[3] See "Descriptive notes."
[4] Supplementary and Final Report of a Geological Reconnoissance of Louisiana, New Orleans, 1873, p. 22.

northern Louisiana--Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
....	25-50	....	....	......	....	....	Quaternary.	Hard..	....	957
....	Spring.	....	....	......	....	....	......	Brine..	Salt spring, with gas.	958
4	1140	....	....	......	....	....	......	......	....	959
4-2½	287.5	127	—24	......	....	....	Sabine..	Brackish	Abandoned.....	960
....	Shallow	....	Flows.	......	....	....	..do..	......	Ever-flowing well..	961
....	825±	95	Flows.	......	....	....	Sabine..	Brackish	....	962
....	64	88	—24	24-62	....	100	Quaternary.	Hard..	....	963
....	Shallow	....	....	......	....	....	......	Brine.	Abandoned salt works	964
....	..do.	....	....	......	....	....	......	..do..	..do.......	965
6	704	285	—100	(3)	....	30	Sabine..	Soft..	Water from 11 different sand beds.	966
....	110	....	—60	......	....	....	......	Good.	Used in boiler...	967
....	Shallow	....	....	......	....	....	......	Brine.	Salt and soda works during the war.	968
8	630	173	—8 +1 +1 +18	167 212 350 630	 30	..	Sabine..	......	Temperature, 70° F.	969
....	Shallow	....	....	......	....	....	......	Brine.	Abandoned salt works	970
....	400	275	....	160	....	Fair.	Sabine..	......	....	971
....	22	....	....	......	....	....	......	......	Ferrell's mineral well	972
4	521	277.5	—100	360-380 418-430 492-520	...	25	Sabine..	Salty; alk'line	....	973
4 6	120 195	203 203	—12 —16	100-120 100-120 190	....	55 55	..do.. ..do..	......	....	974
..	2,103	....	Flows.	537-555 1450-2000	Large. ..do.	....	....	Pure, soft Sulphur	....	975
...	135	....	....	......	....	Large.	Quaternary	Good.	....	976
...	100-135	....	....	......	....	..do.	..do..	Iron..	....	977
...	50	48.8 47.5	...	......	....	....	......	......	....	978
4 5	206	140	[8]Flow [9]—16	200-206	....	....	Cockfield.	Slightly alk'line	Two wells.	979
...	280	....	....	......	....	....	Catahoula	......	....	980
8-6	740	223	....	......	....	None.	......	......	....	981

[5]Geology and Agriculture of Louisiana, pt. 2, 1894, pp. 118, 119.
[6]Foreman for L. B. Clifford Well Co.
[7]Rept. Chief of Eng. for 1902, p. 1566.
[8]In 1901.
[9]In 1902.

Wells and springs in

LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	WEBSTER PARISH						
*982	Bistineau Salt Works.	18N. .	10W .	. . . .	. . . .	. . . .	A. C. Veatch[1] . . .
*983	Cotton Valley . . .	21N. .	10W .	. . . .	Valley Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
984	Dubberly	. . . .	. . . .	. . . .	Valentine Spring .	. . . .	. . . .
984A	Long Springs . . .	19N. .	9W .	6	. . . .	. . . .	. . . .
*985	Minden.	19N. .	9W .	21	Minden Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford
*986	. . . do.	19N. .	9W .	21	. . . do	. . . do	. . . do . . . .
987	do.	19N. .	9W	. . . .	Minden steam laundry.	. . . do	. . . do . . . . .
*988	. . . do.	19N. .	9W .	. . . .	Minden Cotton Oil and Ice Co.	. . . .	S. G. Webb, president.
*989	Spring Hill	23N. .	11W .	. . . .	Pine Woods Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . .
*990	Yellow Pine. . . .	17N. .	9W .	7	Globe Lumber Co.	A. L. Pullin . . .	A. L. Pullin . .
	WEST BATON ROUGE PARISH						
*991	Baton Rouge Junction.	8S . .	12E .	. . . .	Texas and Pacific Rwy.	. . . .	Chas. Anderson, pump man.
992	Lobdell.	7S . .	12E .	. . . .	. . . do	. . . .	B. S. Wathen, chief engineer.
	WEST CARROLL PARISH						
993	Floyd	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . .
	WINN PARISH						
*994	Drakes Salt Works[2]	12N. .	5W .	20–21 28–29	. . . .	. . . .	A. C. Veatch[1] . . .
*995	Prices Salt Works .	13N. .	5W 4W	25 30	. . . .	. . . .	A. C. Veatch[1]
996	Pyburn	13N. .	3W .	34	North Louisiana Lumber Co.	. . . .	North Louisiana Lumber Co.
997	Tannehill	12N. .	3W .	22	Hall & Legin. . .	J. M. Phillips . .	J. M. Phillips .
998	Winnfield	. . . .	. . . .	. . . .	Winnfield ice factory.	L. B. Clifford Well Co.	L. B. Clifford
999	Winnfield, 2 miles south of (Cedar Lick).	. . . .	. . . .	. . . .	. . . .	. . . do	. . . do . . . . . .
1000	Winona	. . . .	. . . .	. . . .	Pine Tree Lumber Co.	. . . .	Pine Tree Lumber Co.

*For additional data see "Descriptive notes," following this table.
[1]Geol. Survey Louisiana, Rept. of 1902, pp. 81-99.
[2]See also No. 904, Goldonna, Natchitoches Parish.

northern Louisiana—Continued

(NORTHERN)—Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
....	10–15	140	....	......	....	....	Nacatoch.	Brine .	Salt made from 1850 to 1892.	982
4	271	220	—48	245–271	....	55	Sabine . .	Soft . .	....	983
....	Spring.	....	....	......	....	....	......	Sulphurreted.	....	984
....	. . do .	....	....	......	....	....	......	Iron . .	Local resort	984A
6	317	192	—28	247–317	....	115	Sabine . .	Soft . .	Used for sawmill and drinking.	985
4	247	192	—28	247	....	110	. . . do . .	. . do . .	....	986
4	251	....	—48	......	....	....	. . . do . .	.....	....	987
8	115	190	— 8	100–115	....	50	. . . do . .	Soft; iron	Temperature, 65.3°F. .	988
3	368	235	{ —14 —28	228–270 338–368 }	....	....	. . . do . .	Soft . .	{ Temperature, 66° F.; lower horizon not developed.	989
4-3	1,015 ±	190	....	......	....	None .	......	.....	Abandoned.	990
....	110	....	....	110	....	Large.	Quaternary	.....	Well fluctuates with the river.	991
....	165	....	....	......	....	. . do .	. . . do . .	Good .	Water in sand and gravel.	992
....	40	....	....	......	....	Small.	. . . do . .	Poor; hard	....	993
{ ...	10–20	....	....	......	....	Large.	Quaternary[4]	Brine .	Saltworks 1800–1865. }	994
...	100–200	....	Flow.	......	....	....	.....	. . do . .	....	
10	1,011	....	+35	......	18	....	Cretaceous	. . do . .	Temperature, 75° F. .	
....	6–15	....	....	......	....	....	Quaternary[4]	. . do . .	Salt works 1840-1869.	995
{ 6 4 }	600 ±	210	—18	....	....	....	Sabine . .	.....	Two wells	996
4	270	120	—10	140–270	....	60	. . . do . .	Soft . .	Water lowers 7 feet when pumping 60 gallons per minute	997
....	700	120	Flows.	......	....	....	. . . do . .	. . do . .	Shells common from 20 to 490 feet.	998
....	268+	....	....	......	....	....	......	.....	Large amount of gas.	999
4	454	210	—90	{ 60 200	} ...	....	Sabine . .	.....	Too much quicksand; well abandoned.	1000

[3]Geol. Survey Louisiana, Rept. of 1902, pp. 51–64.
[4]Leaks from the Cretaceous beds into the bottom-land silts.
[5]Geol. Survey Louisiana, Rept. of 1902, pp. 64–70.

DESCRIPTIVE NOTES

758. It is reported that this well interferes with the railroad well about one-fourth mile distant. Used in boiler, the water forms a large amount of scale, but the addition of a little kerosene is found to furnish almost complete relief.

Analysis of water from well of Union Oil Company at Bunkie, Avoyelles Parish, La.

[By E. W. Brundage]

	Parts per million.
Sodium chloride (Na Cl)	39.5
Sodium sulphate (Na_2SO_4)	7.1
Sodium carbonate (Na_2CO_3)	15.5
Potassium carbonate (K_2CO_3)	1.2
Magnesium carbonate ($MgCO_3$)	183.8
Calcium carbonate ($CaCO_3$)	291.4
Silicon dioxide (silica) (SiO_2)	30 0
Oxides of iron and aluminum (Fe_2O_3. Al_2O_3)	23.0
Organic matter	148.0
Total	739.5

"Characteristics: Odor suggestive of hydrogen sulphide; clear, turbid on standing; considerable sediment. Test with litmus: alkaline."

759. *Section of well of Bunkie Ice and Bottling Company, Bunkie, Avoyelles Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Red clay	0- 70
2. Quicksand	70- 115
3. Gravel	115- 140

762A. Mr. T. L. Grimes reports: "I had the water from my well analyzed by Professor Calwell, of Tulane University, who reported that it contained a little soda, a little magnesia, some lime, and a trace of iron and sulphuric acid. He did not make a quantitative analysis. A well was bored a few miles from me last year that behaved quite strangely. The curbing was gotten down 64 feet by pumping out sand and letting it sink of its own weight, and then it refused to sink any deeper. When they quit work at night there was 4 feet of water in the well, but next morning the water could be dipped from the top with a cup held in the hand. There were constant noises like the escape of gas, and the height of the water changed often, though it was not affected by the stage of water in the river. The

well finally caved in. This well was bored in the center of one of the numerous mounds that are all over this section of the State on the Bluff (Port Hudson) formation."

765. *Record of well of Natchez and Marksville Oil Company, Marksville, Avoyelles Parish, La.*

[By A. W. Myers, driller.]

	Feet.
1. Red clay, with ferruginous concretions	0 - 18
2. Fine red sand	18 - 42
3. Reddish sand and gravel containing good, fresh water	42 - 132
4. Soft sand rock	132 - 136
5. Coarse sand and pebbles	136 - 158
6. Rock	158 - 158.5
7. Medium red sand	158.5- 174
8. Loose rock and bowlders	174 - 177
9. Sand and gravel about the size of a pea	177 - 193
10. Red clay	193 - 199
11. Fine red sand	199 - 206
12. Coarse sand	206 - 214
13. Red clay	214 - 222
14. Rock	222 - 222.5
15. Red sand and clay	222.5- 232
16. Blue sand and gravel	232 - 243
17. Fine sand and gravel	243 - 259
18. Sticky blue clay and bowlders	259 - 318
19. Blue clay, with black particles	318 - 333
20. Red gumbo (stiff clay)	333 - 337
21. Black gumbo	337 - 360
22. Blue clay	360 - 380
23. Medium white sand	380 - 390
24. Blue gumbo	390 - 405
25. Blue clay, with mica	405 - 417
26 Medium white sand	417 - 425
27. Blue shale	425 - 452
28. Very coarse sand (red, white, and blue)	452 - 523
29. Blue and red gumbo	523 - 623
30. Blue shale	623 - 631
31. Blue gumbo	631 - 645
32. Blue shale	645 - 663
33. Sticky blue clay	663 - 697
34 Rock	697 - 698
35. Blue sticky clay and shale	698 - 736

36. Brown clay and sand	736 - 796
37. Blue and red gumbo	796 - 806
38. Blue clay and sand	806 - 822
39. Blue clay, rather hard	822 - 827
40. Coal (lignite)	827 - 827.5
41. Blue gumbo	827.5- 847
42. White rock	847 - 849
43. Blue and red gumbo	849 - 855
44. Gumbo and bowlders, almost black	855 - 926
45. Sand and gravel	926 - 976
46. Sand and bowlders	976 -1,016
47. Sand, with pieces of wood	1,016 -1,034
48. Alternate layers of sand and rock	1,034 -1,062
49. Sand, gravel, and bowlders	1,062 -1,146
50. Impure limestone	1,146 -1,147
51. Blue sand	1,147 -1,205
52. Lime rock	1,205 -1,207
53. Very dark clay	1,207 -1,280
54. Clay with iron pyrites	1,280 -1,282

Total depth December 12, 1902, 1,282 feet; casing 320 feet. In water well screen is placed from 70 to a 100 feet below the surface. There is an abundant supply of water, but it is not very soft.

766. Around Marksville water is generally reached between 40 and 45 feet but the supply is not permanent. Below a thin bed of blue clay at about 65 feet a very good supply is reached, which yields slightly hard water in large quantities.

767. No complete information is available concerning this well. According to the drillers it was 800 feet deep, but it was sounded by Mr. C. B. Couvillion, parish surveyor, about two years after its completion in 1896 and found to be 290 feet deep. As neither the quality nor the supply of water from the well had changed, and the bottom encountered at 290 feet was entirely solid, he concluded that this represented the total depth of the well.

Mr. H. P. Touzet, foreman in charge of the work, writes: "I left the well after driving the 6-inch casing down 200 feet to blue clay. There is an abundance of water to be found about Marksville at depths of 80 to 200 feet. I have no written record referring to the well, but as far as I can remember my successors abandoned the work at a depth of 500 feet, after having bored to that depth with a 4-inch pipe without locating water below the 6-inch casing."

G. D. Harris[1] reports: "At a depth of 230 feet a 5-foot stratum of lignite was penetrated. Mouth of well, 0.3 foot above railroad station, hence approximately 82 feet above tide.

"The gravel bed found between 100 and 160 feet is very much like the

[1] Water-Sup. and Irr. Paper No. 101, United States Geological Survey, 1904, p. 54.

gravel found in the wells in the southwestern Louisiana rice fields. A seam of black clay and lignite was found at 160 feet. The gravel below the lignite was heavily charged with pyrites." It is doubtless from this layer that the water is obtained.

768. *Section of well of Vicksburg, Shreveport and Pacific Railway., Arcadia, Bienville Parish, La.*

[By H. P. Touzet.]

	Feet.
1. Yellow and red clay	0– 30
2. Coarse white sand	30– 40
3. Blue clay	40–100
4. Fine blue sand	100–110
5. Blue clay	110–150
6. Water-bearing gray sand	150–165
7. Calcareous rock	165–175
8. Blue clay	175–275
9. Calcareous rock	275–290
10. Blue clay, mixed with broken rock	290–415
11. Fine white sand	415–465
12. Hard blue clay	465–525
13. Calcareous rock	525–530
14. Very stiff white clay	530–535
15. Blue sand	535–540
16. Blue clay	540–

769. *Analysis of water from mineral well of Dr. J. C. Christian; Arcadia, Bienville Parish, La.*[2]

[By Maurice Bird.]

	Parts per million.
Soluble silica	1,114.9
Iron and alumina	226.7
Lime	573.9
Magnesia	540.2
Potash	11.6
Soda	520
Chlorine	1,647.7
Sulphuric acid	1,538.5

"Mainly sulphates and chlorides of alumina, lime, magnesia, and soda."

770. *Section of well of John Gigleux, Jamestown, Bienville Parish, La.*

	Feet.
1. Surface	0– 18
2. Shell marl, with many *Ostrea sellaeformis* (Claiborne)	18– 30
3 Black clay	30– 90
4. Dark-colored clay, weathering white	90–100
5. Dark sand and clay	100–142
6. Sand, water bearing	142–145

771. *Analysis of brine from Kings Salt Works, Bienville Parish, La.*[3]

[By Maurice Bird.]

	Per cent.
Sodium chloride	6.94
Calcium sulphate	.01
Calcium chloride	.152
Magnesium chloride	.135
Alumina	.148
Other solids	.065

772. *Analysis of brine from Rayburns Salt Works, Bienville Parish, La.*[4]

[By Maurice Bird.]

	Per cent.
Sodium chloride	4.60
Sodium sulphate	.022
Calcium sulphate	.322
Magnesium sulphate	.029
Alumina	.061
Other solid matter, partly in suspension	.03

774. Air lift brings from well fine dark-gray sand, with occasional white quartz grains as large as grains of wheat, and numerous particles of white clay.

Dump heap is, for the most part, fine gray sand, similar to the Shreveport water sand. It shows the following succession of strata:

1. Red clay.
2. Dark-colored clay.
3. Chocolate-colored clay.
4. Gray or greenish-gray sand.

776. *Section of well of Antrim Lumber Company, Antrim, Bossier Parish, La.*

[By L. B. Clifford.]

Sabine:

	Feet.
1. Yellow clay, passing below into blue clay	0– 44
2. Lignite of good quality	44– 48
3. Blue clay	48–160
4. Water-bearing sand	160–263
5. Sand and clay, no water	263–300

[2]Geology and Agriculture of Louisiana, pt. 2, 1892, p. 47. (See page 160)

[3]Geological Survey Louisiana Report of 1902, p. 80.

[4] Geological Survey Louisiana Report of 1902, p. 75.

778. *Section of well of W. H. Smith & Son, Benton, Bossier Parish, La.*

[By J. P. Clifford.]

Sabine.	Feet.
1. Slate-colored clay	0–122
2. Gray rock	122–124
3. Stiff, hard clay	124–140
4. Mahogany-colored clay	140–
5. Water-bearing sand.	
6. "Coal" (lignite)	–350

It is reported that this well flowed for a short time.

782. *Partial section of well of S. H. Bolinger & Co., Bolinger, Bossier Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Yellow clay	0– 14
2. Sand rock	14– 16
3. Yellow clay	16–
4. Blue clay	–162
5. Water-bearing sand	162–235
6. Dark-colored sand and clay, no water	235–315

783. *Section of well at Cash plantation, 3 miles north of Bossier City, Bossier Parish, La.*

[By A. L. Pullin.]

Quaternary (Port Hudson):	Feet.
1. Clay, passing below into fine gravel, containing hard water	0–130
Sabine:	
2. Blue clay	130–155
3. Sand, containing hard water	155–160
4. Blue clay	160–180
5. Sand, with bad water	180–185
6. Blue clay	185–225
7. Lignite	225–
8. Blue clay	–300
9. Brown clay	300–315
10. Water sand; water rises to within 35 feet of surface	315–330

784. *Section of well of Benj. Gray, 2½ miles north of Bossier City, Bossier Parish, La.*

[By A. L. Pullin.]

Quaternary (Port Hudson):	Feet.
1. Soil	0.0– 10.0
2. Soft red sand; becomes coarser and passes into large gravel	10.0– 76.0

Sabine:	
3. Rock (probably a limestone concretion)	76.0– 79.5
4. Blue clay, with layer of lignite at 160 feet.....	79.5–300.0
5. Water-bearing sand (water flowed over top of pipe when well was first sunk)	300.0–330.0

785. *Section of well of Shreveport Cotton-Oil Company, Bossier City, Bossier Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Surface clay, sand and gravel	0– 80
Sabine:	
2. Blue clay, with occasional thin layers of sand...	80–225
3. Water-bearing sand	225–235
4. Blue clay, containing no water	235–600

786. Six-inch pipe, 0–70.5 feet; four-inch pipe. 70.5–168 feet. The six-inch pipe passes through the Quaternary into the Sabine clays.

788. *Section of well of Will Sentell, Lake Point, just above Cedar Bluff, Bossier Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Surface clay, passing below into sand and coarse gravel	0–120
Sabine:	
2. Blue clay	120–232
3. Fine sand, containing good soft water	232–240
4. Dark-colored clay, containing no water	240–600

Completed in 1902. Water lowers readily on pumping.

795. The gravel bed which usually lies at the base of the Quaternary deposits is in this well represented by a coarse sand. No lignite was encountered.

796. *Section of well of John Glassell, at Belcher, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
Quaternary (Port Hudson):	
1. Surface clays, passing below into fine gravel....	c– 96
Sabine:	
2. Clay	96–213
3. Water sand, not passed through	213–225

797. It is reported that the water is at one time soft and at another time hard; this is probably due to a leak in the pipe, which permits the water from the surface gravel to mingle with that in the Sabine sands.

799. *Section of well of M. A. & J. D. Dickson, Dixie, Caddo Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Red sand	0– 6
2. Red buckshot clay	6– 12
3. Red sandy soil, becoming coarser below and passing into coarse sand	12– 60
Sabine:	
4. Blue clay	60–219
5. White sand, water bearing	219–225
Sabine and Midway?:	
6. Blue clay, with occasional rock	225–371

Well completed November, 1902.

800. *Section of well of John Sentell, Cairo plantation, 2½ miles east of Dixie, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
Quaternary (Port Hudson):	
1. Red sand	0– 6
2. Buckshot clay	6– 12
3. Red sandy soil, becoming coarser below and passing into coarse sand containing water	12– 85
Sabine:	
4. Soft white clay	85–160
5. White clay, changing gradually to dark brown and passing into lignite	160–170
6. White sand, water bearing	170–182

A test well put down at this place reached a depth of 391 feet without developing water. A second well, a few feet distant, however, obtained water between 170 and 182 feet.

Well completed April, 1902.

801. *Partial section of well of Glassell & Adger, Sodo Lake, 3 miles southwest of Dixie, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
1. Overflow sand from Cottonwood Bayou	0 – 3
2. Clay	3 – 11
3. Soft red sand	11 – 41
4. White milky clay, mixed with white sand and gravel, with little or no water	41 –121
5. Hard brown clay	121 –131
6. Hard blue clay	131 –255
7. Hard blue rock	255 –278.5
8. Hard black clay	278.5–283.3

9. Hard brown clay	283.3–294.3
10. Dark-gray clay	294.3–310.3
11. Light-gray hard rock	310.3–311
12. Dark clay	311 –364

802. Furrh & Co. report that a very small amount of hard water was obtained. The driller reports shell marl at about 500 feet. Well drilled in 1894.

803. Three-inch casing, 0–132 feet; 2-inch casing, 132-290 feet; 2-inch screens placed at 152–158 and 262–270 feet. Very sandy material from 152 to 290 feet. Well first flowed at 270 feet.

804. *General section of wells in Red River Valley below Shreveport, Caddo Parish, La.*[5]

[By A. L. Pullin.]

	Thickness in feet.
Quaternary (Port Hudson):	
1. Red soil; sandy loam	4– 10
2. Red clay and sand, water bearing. This stratum is clayey above and becomes more sandy below. The lower 5 to 10 feet are quick-sand. This layer is the source of the highly mineral water which is obtained in the driven wells	45– 60
3. Gravel and sand. Firmly bedded, so much so that it is impossible to drive a pipe into it. The gravel sometimes reaches the size of a goose egg. White chert and quartz pebbles are common. The gravel is largest at the top and gradually grows finer until at the base of the stratum it grades into a fine white sand	20– 40
Sabine:	
4. Soft gray sandy clay, containing vegetable remains and occasional shells	8– 16
5. Fine white sand	0– 40
6. Hard tenacious blue clay, called "rubber clay," containing scattered iron concretions about the size of a pea	40–132
7. Indurated sand, water bearing. Furnishes an abundant supply of soft water. Water from this stratum generally rises to within 10 or 20 feet of the surface.	

5Geological Survey Louisiana, Report for 1899 [1900], pp. 179–180

805. *Section of well of Captain Robson, Robson, Caddo Parish, La.*[6]

[By A. L. Pullin.]

	Feet.
Quaternary (Alluvium and Port Hudson):	
1. Red sandy loam	0– 4
2. Fine red clay, with sand	4– 79
3. Red sand, water bearing	79– 82
4. Gravel and sand, same as 3 in well No. 804	82–106
Sabine	
5. Lignitiferous clay with shells	106–118
6. Brown lignite	118–121
7. Good black lignite	121–123
8. "Soapstone," soft white friable clay	123–130
9. Very hard blue limestone	130–131
10. Hard black lignite	131–135
11. Blue clay	135–225
12. Water sand, not passed through	225–

806. According to the best information obtained from several sources and from the sections in adjacent wells, the strata penetrated in this well are as follows:

Section of deep test well of Shreveport Ice Company, Market Street and Cross Bayou, Shreveport, Caddo Parish, La.

	Feet.
Sabine:	
1. Dark-colored clays, with lignite	0-200
2. Gray sand, water bearing	200–250
Midway and Arkadelphia:	
3. Blue clay, with occasional hard streaks of rock; no water	250–961
Nacatoch:	
4. Very hard quartzitic rock	961–
5. Soft sandstone, with occasional hard rock; furnishes artesian salt water with gas	–996

The gas from stratum 5 is used to light the ice factory. Temperature of water, August 22, 1902, 84° F. The water used by the ice company is obtained from three wells developing stratum 3.

807. *Section of test well of Shreveport Waterworks Company, Shreveport, Caddo Parish, La.*

[By H. F. Juengst.]

	Feet.
1. Yellow clay	0 – 38
2. Lignite	38 – 43
3. Yellow clay	43 – 55
4. Sand	55 – 57

[6] Ibid., pp. 180-181

5. Blue clay	57 - 62
6. Black clay	62 - 65
7. Lignite	65 - 70
8. Blue clay	70 -105
9. Clay and sand	105 -115
10. Blue clay	115 -135
11. Yellow clay	135 -160
12. Blue sand and clay	160 -165.5
13. Blue clay	165.5-190.5
14. Lignite	190.5-193.5
15. Yellow clay	193.5-218.5
16. Sand	218.5-228.5
17. Blue clay	228.5-244

Casing, 6-inch, 0-80 feet; 4½-inch, 80-136 feet. An attempt was made to retest the well in 1902, but yielded no results. As the depth to water was at that time only 14 feet, the well had probably caved in and the water-bearing strata had been entirely cut off.

Analysis of water from test well of Shreveport Waterworks Company, Shreveport, Caddo Parish, La.

[By Francis C. Phillips.]

	Parts per million.
Total solids	600
Hardness, expressed in parts per 1,000,000, of carbonate of lime	168
Hardness after boiling one-half hour	154
Chlorine	94
Nitrogen as nitrates	None
Nitrogen as nitrites	None
Free ammonia	.38
Albuminoid ammonia	.04
Oxygen required	1.38

808. The drillers report 83 feet of 4-inch casing, 44 feet of 2½-inch casing, and 15 feet of screen, indicating that a portion of the supply is from above 142 feet. The drilling of this well was carefully watched by Mr. S. Y. Snyder, who has furnished the following report:

Section of well of Henry Rose, Shreveport, Caddo Parish, La.

[By S. Y. Snyder.]

	Feet.
1. Clay and sand	0- 40
2. Dark-blue clay	40- 50
3. Yellow clay	50- 65
4. Quicksand, water bearing	65- 71

5. Hard blue clay	71–150
6. Sand, water bearing	150–165
7. No record	165–175
8. Lignite	175–177
9. Sand	177–272
10. Rock	272

812. The drillers report 4-inch casing, 0-80 feet; 2½-inch casing, 80-169 feet; 10-foot screen, 99-109 feet; 15-foot screen, 148-163 feet; total depth, 324 feet. Completed July, 1901. Cost, $700.

817. Wells Nos. 1 and 2 have 80 feet of 9-inch casing, 60 feet of 4 inch casing and 12 feet of 4-inch screen at the bottom. Well No. 3 has 80 feet of 6-inch casing and 60 feet of 4-inch casing; no screen.

829. Mr. Mayer reports: "In all the wells in this region water rises to within about 15 feet of the surface, is very soft, and free of alkali. It remains pure as crystal at all times, pleasantly cool, and of the same temperature the year round, and extremely wholesome. If allowed to stand exposed to the atmosphere and under ordinary atmospheric temperature it emits an odor of sulphurated hydrogen; no physical change is apparent. The water rises from a stratum of beach sand."

832. *Section of well of A. H. Leonard on Bayou Pierre, 10 miles southeast of Shreveport, Caddo Parish, La.*

[By T. C. Backus]

	Feet.
Quaternary (Port Hudson):	
1. Sandy clay	0– 40
2. Sand and gravel	40– 70
Sabine:	
3. Dark-blue clay	70–130
4. No record	130
5. Water sand	205

Casing, 2½-inch, 0–80 feet; 1½-inch, 80–120 feet.

834. *Section of well in sec. 1, T. 20 N., R. 16 W., Caddo Parish, La.*[7]

	Feet.
Port Hudson:	
1. Fine loamy sand	0– 4
2. Yellow and gray mottled clay, post-oak clay	4–11
3. Red clay, with calcareous concretions in lower part	11–29
4. Blue mud, with vegetable matter and mussel shells	29–46
5. Fine blue sand, not passed through	46–55

7 Geological Survey Louisiana, Report for 1899 [1900], p. 190.

885. *Section of gin well, Uni, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
Quaternary	
1. Stiff red clay	c– 8
2. Fine red sand	8– 15
3. Buckshot soil	15– 20
4. Very fine yellow sand	20– 35
5. White sand, gradually becoming coarser	35– 60
6. Fine gravel, size of grain of corn, water bearing	60– 70
Sabine:	
7. Blue clay	70–190
8. Dry white sand	190–198
Sabine and Midway?:	
9. Brown clay	198–348
Midway?:	
10. Shell marl	348–400
Arkadelphia.	
11. Dark-gray clay	400–650

A second well was drilled to the same depth without obtaining water.

887. *Section of test boring in Ouachita River near Blankston, Caldwell Parish, La. (143.5 miles above mouth of Black River.)*[8]

	Depth in feet.
1. Stiff red clay	0.0
2. Sandy clay	19.7
3. Coarse gray sand, with small percentage of clay	22.4
4. Gray sand	26.3
5. Black sand and clay	51.2

Sections of test borings in Ouachita River near Blankston, Caldwell Parish, La. (144.5 miles above mouth of Black River).[9]

BORING No. 16

1. Brown sand, with small percentage of clay	0.0
2. Gray sand, with some clay	27 89
3. Stiff clay, with some sand	50.

BORING No. 17.

1. Dark-gray sand and clay	0.0
2. Sand and clay	16.41
3. Gray sand and clay	19.69
4. Stiff, sticky blue clay, with small percentage of sand	43.38
5. Stiff and very sticky blue clay	50.

8 Annual Report Chief of Engineers for 1902, pt. 2, 1902 p. 1563.

9 Ibid., p. 1563.

BORING No. 17a.

1. Sand and clay	0.0
2. Brown sand	1.65
3. Gray sand	13.13
4. Gray sand, with small percentage of clay	34.29
5. Gray sand, with larger percentage of clay	42.66
6. Gray sand, with still larger percentage of clay	50.

838. *Section of well of Clark Spur Lumber Company near Clarks, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Clay	1–130
2. Pepper-and-salt water sand	130–145
3. Clay, white and sticky	145–208

840. *Section of well of Clark Spur Lumber Company near Clarks, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Clay	1–110
2. Water sand, red in color	110–150

841. *Section of well at Columbia, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Black sandy loam	0– 7
2. Brown clay	7– 17
3. Blue quicksand, lignite, and mica mixed	17– 57
4. Gray-colored joint clay, with streaks of yellow sand	57– 72
5. Soft blue sandstone	72– 73
6. Coarse white water sand and gravel (iron water)	73– 85
7. Blue clay mixed with shells	85–102
8. Blue flint rock, with gray-colored streaks	102–162
9. Black sticky clay	162–377
10. Chocolate-colored rock	377–388
11. Black sticky clay	388–422
12. Clay, with iron pyrite	422–423
13. Fine sand, with lignite and mica, containing artesian water	423–503

842. *Section of test boring in Ouachita River at Standfield Place, 2 miles below Columbia, Caldwell Parish, La. (123.3 miles above mouth of Black River).*[10]

	Depth in feet.
1. Yellowish sand and clay	0.0
2. Yellowish sand	1.62
3. Mud, with gray sand	19.69
4. Gray sand	22.31
5. Mud, with dark sand	25.10
6. Sand	41.01
7. Mud, with sand	43.47

843. *Section of test boring in Ouachita River at Columbia, Caldwell Parish, La. (125.6 miles above mouth of Black River).*[10]

	Depth in feet.
1. Reddish-yellow sand and clay	0.0
2. Reddish-yellow sand	8.20
3. Gray sand	9.84
4. Mud, with sand	15.75
5. Dark-gray sand	17.39
6. Mud, with small percentage of sand	24.28
7. Gray sand	24.61
8. Mud, with gray sand	29 03
9. Gray sand	32.31
10. Sand, with small percentage of mud	36 58
11. Gray sand	40.68
12. Mud and sand	50.59
13. Mud aud sand	52.49

844. *Section of test boring in Ouachita River 1 mile above Columbia, Caldwell Parish, La. (126.9 miles above mouth of Black River).*[11]

	Depth in feet.
1. Brown sand and clay	0.0
2. Gray sand	16.41
3. Gray-brown sand	32.81
4. Blue-gray sand, with small percentage of clay and pieces of coal	48.23
5. Blue-gray sand, with some clay and gravel	73.43
6. Clay, with small percentage of sand and pieces of rock	100.03
7. Very coarse sand and clay	113.19
8. Gray sand	120.47
9. Gray sand, with small percentage of clay	177.07
10. Gray sand, with small percentage of clay	220.14

[10] Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1561.
[11] Ibid., p. 1561.

845. *Section of test boring in Ouachita River 2 miles above Columbia, Caldwell Parish, La. (127.5 miles above mouth of Black River).*[12]

	Depth in Feet.
1. Soft, boggy sand and mud, full of trash.... ...	0 0
2. Gray sand, with bark and wood	24.60
3. Gray sand....	45.57

846. *Section of test boring in Ouachita River, 3 miles above Columbia, Calwell Parish, La. (128.1 miles above mouth of Black River.)*[12]

	Depth in Feet.
1. Brown sand and clay...........	0.0
2. Gray-brown sand, with some clay..............	17.02
3. Gray-brown sand, with some clay..............	52.49

847. *Section of test borings in Ouachita River at Calls Landing, Caldwell Parish, La. (134.5 miles above mouth of Black River).*[13]

BORING No. 14.

	Depth in Feet.
1. Brown sand, with some clay.................	0.0
2. Gray sand............................	9 84
3. Stiff gray-blue sand and clay.....	31.08
4. Stiff gray-blue sand and clay..................	50.86

BORING No. 14a.

1. Brown sandy clay.............................	0.0
2. Gray sand	6.56
3. Stiff gray-blue sand and clay..................	39.76
4. Stiff gray-blue sand and clay.................	50.00

848. *Section of test boring in Ouachita River at Lower Breston place, Caldwell Parish, La. (132.2 miles above mouth of Black River).*[14]

	Depth in Feet.
1. Very soft sand and mud.....................	0.0
2. Brown sand, with small percentage of clay.....	9.84
3. Lot of trash, principally wood................	13.12
4. Fine, clean gray sand........................	16.40
5. Coarse, clean gray sand.........	19 68
6. Coarse, clean gray sand......................	45.57

[12] Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1561.
[13] Ibid., p. 1563.
[14] Ibid., p. 1562.

849. *Section of test boring in Ouachita River at Upper Breston place, Caldwell Parish, La. (133.3 miles above mouth of Black River).*[14]

BORING No. 13.

	Depth in Feet.
1. Brown sand and mud	0.0
2. Fine gray sand, full of trash	16.40
3. Coarse gray sand	34.78
4. Stiff blue mud, with some sand and pieces of rock	44.06
5. Stiff blue mud, with some sand and pieces of rock	52.59

BORING No. 13a.

1. Soft brown sand	0.0
2. Fine gray sand, with some trash	16.40
3. Coarse gray sand	32.81
4. Stiff blue mud, with some sand and pieces of rock	47.64
5. Stiff blue mud, with some sand and pieces of rock	52.49

850. *Section of test boring in Ouachita River at Smithland, Caldwell Parish, La. (131.2 miles above mouth of Black River).*[15]

	Depth in Feet.
1. Brown sand, with some clay	0.0
2. Log	9.84
3. Gray sand, with small percentage of clay	10.50
4. Clean gray sand	16.41
5. Gray-brown sand	21.33
6. Gray sand, with clay in lumps or layers	32.81
7. Gray sand, with larger percentage of clay	34.16
8. Coal (lignite)	46.03
9. Gray sand and some clay	46.69

851. *Section of test boring in Black River (37.9 miles above mouth) at New Hope place, Catahoula Parish, La.*[16]

BORING No. 1.

	Depth in Feet.
1. Sandy clay	0.0
2. Sand and lumps of mud	6.57
3. Dark sand	9.85
4. Dark sand	41.02

[14] Ibid., p. 1562.

[15] Ann. Rept. Chief of Engineers, 1902, pt. 2, p. 1562.

[16] Ibid., p. 1560.

BORING No. 1a.

1. Sandy clay	0.0
2. Dark-gray sand	3.93
3. Dark sand and mud	12.47
4. Blue mud	14.11
5. Mud and sand	18.21
6. Dark sand	29.53
7. Dark sand	39.37

852. *Section of test boring in Black River (42.2 miles above mouth) at Star View place, Catahoula Parish, La.*[16]

	Depth in Feet.
1. Brown sand and mud	0.0
2. Gray sand	6.58
3. Gray sand	50.00

853. *Section of test boring in Black River (51.4 miles above mouth) at Jones Bayou, Catahoula Parish, La.*[16]

	Depth per Feet.
1. Gray-brown sand	0.0
2. Clean gray sand	9.85
3. Clean gray sand	50.00

854. Salt springs are described in this region by a number of the early explorers.[17] They were visited by Hopkins in 1871 and pronounced to be of little economic value.

855. Mr. Thomas W. Robertson, field assistant, visited this well August 18, 1902, and obtained from Mr. A. A. Arnold, head driller, and Dr. J. C. Harden, fossils found at a depth of 1,000 to 1,250 feet. These have been pronounced Jackson (Eocene) by Prof. G. D. Harris. The depth at which they were found confirms the dip observations made on Ouachita River between Stock Landing and Carter Landing.[18]

Dr. Harden, with whom the drillers stayed, was greatly interested in the well and kindly allowed Mr. Robertson to copy the following from his personal memorandum. It should be noted that it differs materially from the record furnished by the president of the company, and given below, which on the whole more nearly agrees with the known structure.

Section of well of Catahoula Oil and Development Company, Leland, Catahoula Parish, La.

[By Dr. J. C. Harden.]

	Feet.
1. No record	0 – 40
2. Coarse gray sandstone, containing pure freestone water	40 – 60

[16] Ibid., p. 1560.
[17] Geol. Survey Louisiana, Rept. of 1902, pp. 91–92.
[18] Ibid., p. 164.

3. Black clay, with pebbles	60	70
4. Soft sandstone, with water	70	246
5. Dark-green clay	246	546
6. Sandstone	546	559
7. Coarse red and white sand	559	601
8. Black and yellow clays	601	666
9. Soft sandstone	666	670.5
10. Sand, with soft, warm water	670.5	700.5
11. Black clay	700.5	760.5
12. Yellow clay	760.5	775.5
13. Fine gray sand, with water	775.5	800.5
14. Black clay	800.5	875.5
15. No record	875.5	1,000
16. Clay, with shells (Jackson)	1,000	1,250
17. No record	1,250	1,300
18. Very black formation, old seaweed, mud, and lignite (Cockfield)	1,300	1,500
19. Sand, with artesian salt water	1,500	1,645
20. Rock, "gypsum"	1,645	1,651
21. Very fine gray gypsum?; sand; water not artesian	1,651	1,701
22. Black and yellow clay	1,701	1,751
23. Rock	1,751	1,764
24. No record	1,764	1,864

"Pipe was withdrawn from 1,864 to 900 feet, when an explosion occurred which could be heard over three-fourths mile; then a gusher of very foul-smelling gas, mud, lignite, and salty water shot up over 100 feet. This contained some oil. Flow continued for twenty-two hours, when it stopped by choking. Before flow stopped salty water became quite clear."

The president, Mr. S. McDowell, furnished the following record in February, 1903:

Section of well of Catahoula Oil and Development Company, Leland, Catahoula Parish, La.

[By S. McDowell, president.]

	Feet.	
1. Gray-mottled clay	0	60
2. Quicksand, with water	60	80
3. Sandstone	80	130
4. Blue or green clays	130	370
5. Water-bearing sand	370	
6. Blue or green clays		1,550
7. Artesian salt water	1,550	

No water was encountered between the 370-foot sand stratum and 1,550 feet.

Section of test well of St. Louis, Iron Mountain and Southern Railway, Olla, Catahoula Parish, La.

[From records in the office of E. Fisher, chief engineer of bridges and buildings.]

	Feet
1. Clay	0–242
2. Water and sand	242–254
3. Streaks of sand and clay	254–257
4. Fine sand, with layers of sand rock and some water	257–314
5. Clay and sand in layers	314–328
6. Soapstone	328–341
7. Gray, hard clay, and black, tough clay or soapstone	341–358
8. Fine sand, water trace	358–364
9. Clay and fine sand, not much water	364–369
10. Fine sand, not much water	369–374

859. *Section of test boring in Ouachita River at Catahoula Shoals, Catahoula Parish, La., (77 miles above mouth of Black River).*[19]

	Depth in feet.
1. Sandy mud	0.0
2. Sand, clay and gravel	.99
3. Gravel	3.28
4. Gray sand	15.75
5. Blue-brown sandy clay	30.35
6. Blue-gray rock	52.50
7. Very hard blue gray clay or soft rock	54.33
8. Soft blue-gray rock	76.18
9. Blue sandy clay	86.32
10. Gray rock	139.67
11. Blue sandy clay	140
12. Fine gray sand; water flowed at the rate of 3,600 gallons per hour	158 07
13. Fine gray sand; water flowed at the rate of 3,600 gallons per hour	197.51

862. Lockett[20] gives the following regarding this locality: "In the vicinity of La Croix Ferry, and near the mouth of Trout Creek, is a small area of about 1 mile square, peculiarly characterized by numerous sulphur springs. The best known of these are on the eastern bank of Trout Creek, known as the Catahoula White Sulphur, and now owned by Mrs. Ward. Her husband first opened these springs to the public in 1846, and for many years they were a fashionable resort for the planters of Rapides and other parishes. Their waters were thought to be beneficial to those afflicted with liver complaint, dyspepsia and all kinds of cutaneous diseases.

"One mile from Wards Springs, on the opposite side of Trout Creek, are the sulphur springs of Captain Welch, which are better, more numerous, and stronger than the former, but are not so well known, from never having been opened to the public."

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19 Ann. Rept. Chief of Engineers, 1902, pt. 2, p. 1560.

20 Ann. Rept. Louisiana State Univ. for 1869, 1870, pp. 56, 57.

868. *Analysis of spring water from sec., 15, T. 21 N., R. 4 W., Claiborne Parish, La.*[21]

	Parts per million.
Silica	52.4
Peroxide of iron and alumina	13.2
Lime	23.9
Magnesia	7.01
Potash	4.78
Soda	22.9
Sulphuric anhydride	22 9
Chlorine	16.59
Carbonic acid	35 9
Oxygen absorbed from potassium permanganate in three hours	.30

No ammonia and mere traces of nitrates, nitrites, and phosphoric acid.

867. *Section of Texas and Pacific Railway well at Fish Pond, Concordia, Parish, La.*

[By C. H. Camberlain.]

	Feet.
Alluvium and Port Hudson:	
1. Top soil and clay	0– 40
2. Blue clay, with streaks of sand	40– 70
3. Quicksand	70– 95
4. Clay and cottonwood drift	95–100
5. Loose stones and gravel	100–105
6. Sharp water sand and gravel	105–145

871. *Section of R. G. Hedrick's test well, 2 1-2 miles northeast of Frierson, De Soto Parish, La.*

	Feet.
Sabine:	
1. Gray sands and clays, with lignite	0– 241
2. Coarse white sand; lost water in large quantities	241– 281
Midway and Arkadelphia:	
3. Dark clay	281– 301
4. Rock	301– 302
5. Dark-colored laminated lignitiferous clay, with large concretions and occasional layers of iron pyrite	302– 901
6. Harder clay; did not cave as badly as that above	9 1– 998

[21] Preliminary report on the hill lands south of the Vicksburg, Shreveport and Pacific Railway to Alexandria: Geol. and Agric. of La., pt. 2, 1893, p. 118.

Nacatoch:

7. Indurated sand, containing Foraminifera and Ostracoda. Furnishes artesian salt water ...	998–

Marlbrook:

8. Blue clay....	–1,275
9. White limestone; gas at 1,300 feet, (Saratoga?)..	1,275–1,300
10. Light clayey shale, with some sand......... ...	1,300–1,500

Diameter, 8 inches, 0–380 feet; 6 inches, 380–913 feet; 4 inches, 913–1,500 feet. Temperature of artesian water August 25, 1902, 70° F. Elevation of gound, 198.3 feet; top of 4-inch pipe, 203.5 feet above mean Gulf level.

872. *Section of Mississippi River Commission test boring, Hays Landing, East Carroll Parish, La.*[22]

[By E. W. Hilgard.]

	Feet.
Alluvium:	
1. Noncalcareous clayey silt, with abundant vegetable matter not lignitized..................	0– 56
Port Hudson:	
2. Coarse sand, with gravel and grains of lignite A clay streak occurs at 82.5 to 82.6..........	56–109
"Upper Claiborne" (Jackson):	
3. Whitish greensand marl. On washing and settling the greensand falls to the bottom, the red sand occupies the middle, and the calcareous débris lies on top.....................	127–132
4. Greensand marl like the last, with calcareous concretions containing shell fragments........	132–135
5. Concretions from marl bed, with shell fragments	145–150
6. Bluish clay, with lignite grains	158–160
7. Fine sand of a clay color with greensand.......	166–176
8. Bluish clayey silt, with lignite grains...........	176–181

"This boring at Hayes Landing, about 5½ miles southwest from the boring at Lake Providence (873), shows in its upper portion the same unusual variety of materials as No. 873. For that very reason it is extremely probable that if it were of the older formation the corresponding fossils would be easily found. The depth of the alluvium here may therefore probably be placed at 56.8 feet; from this depth to that of 109 feet there can be no doubt of the true character of the older or 'bottom gravel.'"

[22] Ann. Rept. Miss. River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884, pp. 494, 496.

Harris[23] has identified the following forms from this well: *Leda multilineata* (radial marking on anterior only), *Leda*, depth 135 feet; *Venericardia planicosta* and *V. rotunda*, depth 137 feet.

These forms, together with those obtained from the other borings along the river, indicate that this formation is Jackson rather than Claiborne.

878. *Section of Mississippi River Commission test boring at Lake Providence, East Carroll Parish, La.*[24]

[By E. W. Hilgard.]

	Feet.
Alluvium:	
1. Yellowish noncalcareous silt, with macerated vegetable matter, varying in the proportions of sand and clay every few feet	0- 9.6
2. Blue clay	9.6- 15.6
3. Yellowish sand, slightly coherent	15.6- 29
4. Blackish-blue clay	29 - 30
5. Grayish-yellow sand, slightly coherent	30 - 42.9
Port Hudson:	
6. Loose sand, with grains of lignite	54.8-
7. Fine brownish silt, darker below, with lignite in grains	56 - 82
8. Bluish-gray clay	82 - 84
9. Clayey silt of a terra-cotta color; abundant lignite grains	100.5-101
10. Grayish-yellow sand; vegetable matter abundant	101 -103.2
11. Brownish clay	103.2-104
12. Coarse sand, with chert pebbles	109 -127.6
13. Black lignite	127 -131.5
14. Whitish-blue sandy clay	131.5-170
15. Fine yellowish clayey sand	170 -191
16. Gray sand, with clayey streaks	191 -247
17. Blackish-brown clay	247 -248

"Boring No. 2, the deep boring at Lake Providence town, is one of the most interesting, not only on account of the great depth reached (248 feet) and the great variety of materials encountered, but mainly from the fact that at this great depth the Tertiary strata (contrary to the impression of the engineer in charge) have not been reached." For the general run of wells in this section the writer is inclined to regard stratum No. 12 as the base of the Quaternary or Port Hudson deposits.

[23] Geol. Survey Lousiana, Rept. of 1902, p. 23.

[24] Ann. Rept. Miss. River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884 pp. 494, 496.

876 *Section of well at Lake Providence, East Carroll Parish, La.*[25]

[By John L. Kennedy.]

	Feet.
1. Black, blue, and red loam	0–10
2. Fine sand	10–19
3. Coarse water-bearing sand	19–34
4. "Concrete"	34–38
5. Water-bearing sand	38–77
6. "Concrete"	77–79
7. Sand	79–85
8. "Concrete"	85–86
9. Water sand	86–93

"Abandoned at 112 feet, the water being found too ferruginous for general purposes."

877. *Section of town well at Colfax, Grant Parish, La.*

[By L. B. Hart.]

	Feet.
Port Hudson:	
1. Surface	0– 70
2. Water-bearing sand and gravel	70– 130
Jackson:	
3. Very hard clay	130– 300
4. Blue joint clay	300– 550
Cockfield:	
5. Fine quicksand	550– 650
6. Hard brown clay	650– 800
7. Sand rock	800– 835
8. Alternate layers of quicksand and black clay	835–1,000
9. Sand rock	1,000–1,060
10. Loose sand	1,060–1,100
11. Hard sandstone	1,100–1,128
12. Hard white clay, not passed through	1,128–

"Pipe pulled back and set at 1,103 feet. This water proved to be very salty or full of soda. It seemed to be propelled by gases, the water rising in a pipe 65 feet above the surface. The natural flow is 60,000 gallons for twenty-four hours."

Mr. R. S. Cameron reports that below 150 feet gypsum and shells (principally small spirals) were quite common. No shells were found above 150 feet.[26]

[25]Geol. Survey Louisiana, Rept. of 1902, p. 232.

[26]Shells are incorrectly reported above 150 feet in Geol. Survey Louisiana, Rept. of 1902, p. 211.

880. The artesian water obtained in the sandstone at 255 feet is used entirely for drinking. The well was continued to 910 feet without obtaining water except at 500 feet, where an impotable water was found in a blue mud.

881. *Section of well of Louisiana Lumber Company Limited, Rochelle, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. White dirt soil	1– 45
2. Fine sand, with sticks, logs and acorns	45– 56
3. Alternate layers of blue clay and flint rock, with streaks of salt water in fine sand	56–555
4. Alternate layers of fine white sand and porous chocolate-colored rock, in layers 6 to 12 inches thick; furnishes artesian salt water	555–565

Mr. F. T. Boles, manager of the Lord & Bushnell Lumber Company, Chicago, reports: "Well at Rochelle was 1,100 feet deep; at that depth brackish water with gas was obtained. One of our men who worked on the job reports that a slight flow of fairly good water was obtained at 700 feet." This refers to the same well reported by Mr. Shanks.

882. *Section of well of St. Louis, Iron Mountain and Southern Railway at Sandspur, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. Red clay	0–50
2. Cemented gravel	50–60
3. Coarse Gravel and sand	60–75

Well finished with a Cook strainer 14 feet long.

883. *Section of well of S. Hopper Mill Company, Stay, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. White and yellow clay	1–20
2. Quicksand	20–30
3. Blue clay	30–60
4. Coarse gravel and white sand	60–78

884. *Section of well of Davis Brothers, Ansley, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Red clay	0– 22
2. Blue clay and rock	22–190
3. Gray sand, water bearing	190–245

885. *Section of well of Huie-Hodge Lumber Company, Hodge, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Marl and blue clay	0–292
2. Gray sand, water-bearing	292–300

886. Mr. L. B. Clifford writes: "In the Jonesboro well there were about 70 feet of lignite in different layers; balance was blue marl, with occasional rocks. The water-bearing sand was gray and about 30 feet thick."

887. *Section of well of Wyatt Lumber Company, Wyatt, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne:	Feet.
1. Blue shell marl	0– 70
Claiborne and Sabine:	
2. Blue clay and layers of rock	70–208
3. Hard packed sand, layers of blue rock at bottom	208–242
4. Fine white sand, water bearing	242–252
5. Hard-packed gray sand and rock	252–272
6. Gray sand, water bearing	272–302

888. *Analyses of spring water from Chautauqua grounds; near Ruston, Lincoln Parish, La.*[28]

[By Maurice Bird.]

Constituents (in parts per million.)	Griffen Springs, No. 1.	Griffen Springs, No. 2.
Soluble silica	47.9	45.5
Iron and alumina	26.3	41.0
Lime	26.3	20 3
Magnesia	11.6	15.0
Potash	Trace.	Trace.
Soda	19.0	20.3
Chlorine	7.2	5 5
Sulphuric acid	11.5	12.8
Phosphoric acid	Trace.	Trace.
Nitrogen as nitrates	Trace.	Trace.
Nitrogen as nitrites	None.	None.
Nitrogen as ammonia	None	None.
Carbonic acid	Not determined	Not determined.

Both springs are slightly chalybeate.

890. *Section of well of Ruston Waterworks, Ruston, Lincoln Parish, La.*

[By L. B. Clifford.]

		Feet.
1.	Sand	0– 18
2.	Light-blue clay	18– 59
3.	Water-bearing sand	59– 60
4.	Rock	60– 61
5.	Blue clay, with limestone concretion	61– 67
6.	Water-bearing sand	67– 68
7.	Clay	68– 69
8.	Rock	69– 74
9.	Water-bearing sand	74– 76
10.	Rock	76– 81
11.	Water-bearing sand	81– 84
12.	Rock	84– 85
13.	Water-bearing sand	85– 86
14.	Clay, with occasional rocks	86–120
15.	Water-bearing sand	120–126
16.	Clay, with occasional rocks	126–152
17.	Water-bearing sand	152–154
18.	Clay, with occasional rocks	154–373
19.	Water-bearing sand	373–425

Pipe was perforated between 120 and 126 feet and between 373 and 425 feet.

[28] Geology and Agriculture of Louisiana, pt. 1, 1892, p. 47.

893. *Section of Vicksburg, Shreveport and Pacific Railway test well at Delta, Madison Parish, La.*

[By R. B. Coxe.]

Alluvium and Port Hudson:	Feet.
1. Clay	0– 12
2. Quick sand	12– 50
3. Light clay, passing below into sand and gravel	50– 118
4. Coarse gray water-bearing sand	118– 135
5. Clay; no water	135–1,200±

894. Pronounced by State experiment station a good drinking water.

895. "Wells in the valleys and on the bayous are generally from 25 to 50 feet deep; on the hills from 60 to 150 feet. The water is in most cases slightly hard. There is a flowing well in T. 19 N., R. 16 E., and one that flows at times in the channel of Bonne Idee Bayou in T. 21 N., R. 7 E. Sulphur springs abound along upper Bartholomew and Boeuf rivers."

896. *Section of well at court-house, Bastrop, Morehouse Parish, La.*

[By W. A. Harrington.]

Port Hudson:	Feet.
1. Clay and soil	0– 25
2. Dry sand	25– 65
3. Medium coarse sand, filled with good, almost pure, water	65–153
4. Hardpan	153–

897. *Section of well of St. Louis, Iron Mountain and Southern Railway, Collinston, Morehouse Parish, La.*

[By C. H. Winters.]

Alluvium and Port Hudson:	Feet.
1. Sandy clay and soil	0–10
2. Hard gumbo and yellow clay	10–64
3. Fine sand	64–68
4. Coarse sand and gravel	68–71
5. Fine sand	71–78
6. Gravel and sand	78–81

Well is furnished with a No. 4 Cook well strainer. When pumping 140 gallons per minute the water level remains unchanged.

898. *Section of well of St. Louis, Iron Mountain and Southern Railway, Mer Rouge, Morehouse Parish, La.*

[By Oscar Shanks.]

	Feet.
Port Hudson:	
1. Black soil	0– 6
2. Stiff clay	6–79
3. Water-bearing sand	79–89

901. Mr. D. G. Petty reports: "A well 1 inch in diameter was sunk here in the early part of 1902, and at 412 feet flowed from the pipe 20 feet above ground for half a day. The pipe was on a rock, and as that was the time of the oil excitement the workmen concluded to go through the rock and strike oil. The rock was penetrated and the water ceased to flow. Nothing more has been done to the well except to remove the pipe. The pipe was never fast and one man could easily turn it at any time. The water was very good for drinking. Did not test for hard or soft.

904. *Partial section of test well at Drakes Salt Works, sec. 21, T. 12 N., R. 5 W., Natchitoches Parish, La.*

[By H. H. Jones.]

	Feet.
1. Yellow sand clay	0– 5
2. White sand, with water which steams all right in a boiler, but turns deep red and coats everything with a salty crust	5– 42
3. Cypress log, very much decayed, charred on one side	42– 43
4. Soft sand, gravel, and streaks of clay of various colors so mixed in drilling that we could not classify or give stratification	43–318
5. Very porous crystalline limestone; crevices filled with white and yellow calcite crystals	318–475

"At 150 feet a foam found on the water which tasted very much of alum, puckering the mouth very much."

Samples from stratum 5 are in every way identical with the limestone found at the Winnfield "Marble Quarry."

906. *Partial section of well of J. W. Cockerham, Jr., Luella, Natchitoches Parish, La.*

	Feet.
Alluvium and Port Hudson:	
1. Surface loam	0 – 36
Transition:	
2. Sand and gravel, with large lignitized cottonwood (?) log at 270 feet.	36 –300
Sabine:	
3. Rock	300 –304
4. Blue clay, with occasional rock several feet thick	304 –640
5. Sand, with artesian salt water	640 –
6. Fossiliferous sand, with artesian salt water	700.5–707

Mr. Cockerham has three wells on his place which obtain water from the sand and gravel stratum No. 2, and which are, respectively, 36, 86, and 106 feet deep. The water in these stands from 18 to 21 feet below the surface, and from the 36-foot well a supply of 10 gallons per minute has been pumped without affecting the water level.

908. *Section of well of Montrose Lumber Company, Montrose, Natchitoches Parish, La.*

	Feet.
Alluvium and Port Hudson:	
1. Surface clay and loam	0– 80
2. Quicksand, abundant supply of water, but it can not be used in boilers	80–180
Jackson and Cockfield:	
3. Blue clay, with fossil shells; no water	180–496

Well sunk in January, 1899. Judging from the depth of the water-bearing sand in the Weaver spur well, water should be obtained at this place at a depth of about 600 feet. (P. 138; Pl. XXXVIII, sec. E)

910. *Section of well at waterworks, Natchitoches, Natchitoches Parish, La.*

[By Judge C. H. Levy.]

	Feet.
Claiborne:	
1. Red clay	0– 5
2. Blue clay	5–12
3. Red clay	12–13
4. Blue and red sandy clay	13–16

Sabine:

5. Fine gray quicksand, very variable in thickness.	16–39
6. Black sandy clay	39–40
7. Coarse gray sand, not passed through	40–64

The well at the waterworks consists of a dug well, 30 feet in diameter and 19 feet deep, in which five 1½-inch pipes and one 3-inch pipe have been driven to a depth of 40 to 45 feet below the bottom of the well. The water flows rapidly from the top of these pipes into the well.

911. The following record has been prepared from the statements of President Caldwell, and from data collected on the ground while the well was being drilled:

Section of well of Normal School, Natchitoches, Natchitoches Parish, La.

1. Red and chocolate clays	0 - 34
2. Soft sandstone, iron stained	34 - 35.5
3. Gray sand, with a moderate supply of very salty water, rising to within 14 inches of the surface	35.5- 38
4. Alternate beds of blue-gray and red-gray sandstone and blue clay, with occasional bits of pyrite and lignite	38 - 96
5. Very fine, nearly pure white sand, with a large supply of water, not distinctly salt	96 -108
6. Chocolate clay, blue clay, and thin beds of sand	108 -134
7. Iron pyrite	134 -144
8. Coarse, white rounded sand	144 -156
9. Pyrite	156 -160
10. Alternate layers of clay and sand, with one or two thin beds of impure lignite	160 -462
11. Shells and gravel	462 -496
12. Blue clay	496 -558
13. Lignite	558 -558.5
14. Blue clay	558.5-560
15. Lignite	560 -571
16. Blue clay, with occasional seams of lignite	571 -637
17. Gray clay, with limestone concretions	637 -680
18. Lignite	680 -700
19. Sandstone	700 -704
20. Soft blue clay	704 -710
21. Light-gray sand, with artesian salt water and gas	710 -726

Harris[26] adds the following information, obtained from the foreman of the Andrews Well Company:

[26] Geol. Survey Louisiana, Rept. of 1902, p. 210.

Partial section of well of Normal School, Natchitoches, Natchitoches Parish, La.

	Feet.
1. Greenish brittle clay, with shells	0-547
2. Lignite	547-558
3. Clay, with shells	558-678
4. Bowlder	678-681
5. Clay (no shells), rock, fine sand	681-728

918. *Analysis of water from Iron Springs, near Natchitoches, Natchitoches Parish, La.*[29]

[By Maurice Bird.]

	Parts per million.
Silica	64.0
Iron and aluminum oxides	8.0
Lime (CaO)	12.0
Magnesia	9.3
Sulphuric acid (SO_3)	20.6
Potash	4.0
Soda	22.0
Chlorine	17.4

"Water is colorless, but contains a little brown suspended matter; it is neutral to litmus paper and practically tasteless."

911. *Analysis of water from Breazeale Spring, 2 miles northwest of Natchitoches, Natchitoches Parish, La.*[30]

[By Maurice Bird.]

	Parts per million.
Silica	55.0
Iron and aluminum oxides	4.0
Lime (CaO)	9.0
Magnesia	5.7
Sulphuric acid (SO_3)	20.6
Potash	4.0
Soda	22.0
Chlorine	17.4

"Water is clear and colorless, neutral to litmus paper, and practically tasteless."

[29] Geol. Survey Louisiana, Rept. for 1899 [1900], p. 148.
[30] Ibid., p. 148.

918. *Sections of test borings in Ouachita River near Bosco, Ouachita Parish, La. (155 miles above mouth of Black River).*[31]

BORING No. 18.

	Depth in feet.
1. Yellow sand	0.0
2. Gray sand, with small percentage of clay	13.12
3. Mud	36.09
4. Mud, with small percentage of sand	43.96

BORING No. 18a.

1. Fine, clean sand	0.0
2. Fine gray sand and mud	4.43
3. Coarse gray sand and blue mud, with gravel	17.06
4. Clean gray sand	17.56
5. Gray sand and mud	23.46
6. Mud, with small percentage of sand	24.78
7. Mud	25.10
8. Mud	32.14

919. The following section of the well of the Louisiana Oil Company was prepared from samples at the well:

Description of samples from well of Louisiana Oil Company, 3 miles southeast of Cheniere, Ouachita Parish, La.

[By A. C. Veatch.]

	Depth in feet.
1. Dark clay	10
2. Light, sandy clay	35
3. Mottled clay	45
4. Pebbly clay	55
5. Dark, stiff clay	65, 75
6. Dark, sandy clay	85, 95, 105
7. Dark sand	115
8. Dark sand, with small shells	125, 135, 145, 155
9. Dark, sandy clay	165, 175, 185, 195
10. Light clay	205
11. Light clay and sand	215
12. Hard clay	225, 235, 245, 255
13. White sand	265–275
14. Sand and clay	285, 295
15. Clay, with shells	305, 315

[31] Ann. Rept. Chief of Engineers for 1902, p. 1564.

16.	Lignitic clay	325
17.	Lignite and sand	335, 345
18.	Sand	355, 430
19.	Hard clay	445
20.	Clay and sand	455
21.	Gray sand, reported to contain artesian water	465–515

920. *Sections of test borings in Ouachita River near Logtown, Ouachita Parish, La. (160 1 miles above mouth of Black River).*[32]

BORING No. 19.

		Depth in feet.
1.	Brown sand and trash	0.0
2.	Brown sand	1.64
3.	Sand and coarse gravel	13.12
4.	Very stiff, sticky blue-black clay	23.78
5.	Very stiff, blue-black clay, with pockets and streaks of greensand and shells, also many small pieces of rock, some as large as a hen's egg	37.73–50

BORING No. 19a.

1.	Brown sandy clay	0 0
2.	Brown sand	1.97
3.	White sand	13.13
4.	Sand and coarse gravel	19.69
5.	Sand and coarse gravel, with small percentage of clay	28.12
6.	Stiff, sticky blue-black clay	34.78
7.	Very stiff clay, with pockets and streaks of green sand	42.65
8.	Very stiff clay, with pockets and streaks of greensand marl; also several pieces of rock about the size of a hen's egg	49.22–50

[32]Ann. Rept. Chief of Engineers for 1902, p. 1564.

921. *Analyses of waters from wells of the Consolidated Ice Company, Monroe, Ouachita Parish, La* [33]

[By Maurice Bird.]

Constituents (in parts per million).	Jackson well.	Boone well.
Soluble silica	14.022	50.958
Iron and alumina	27.018	30.438
Lime	14 022	17.955
Magnesia	2.394	3.410
Potash	3.762	3.762
Soda	224.694	259 407
Chlorine	24 795	27.018
Sulphuric acid	7.524	9.4 5
Phosphoric acid	12 825	17 784
Nitrogen as nitrates	None.	None.
Nitrogen as nitrites	None.	None.
Nitrogen as ammonia	None.	None.
Carbonic acid	177.840	87.039

922. *Section of well of Consolidated Ice Company, Monroe, Ouachita Parish, La.*

	Feet.
Port Hudson:	
1. Clay and earth	0– 40
2. Sand, water bearing	40– 60
3. Clay	60– 65
4. Water-bearing sand	65– 75
5. Hard clay	75– 90
6. Coarse sand and gravel	90– 95
Claiborne and Sabine?:	
7. Blue clay mixed with sand and a few layers of rock	95–250
Sabine:	
8. Sand, with some black substance like lignite; water begins to flow at 250 feet and flow increases with depth	250–400

923. There are three wells at the waterworks, but because of the large amount of mineral matter the water is used only in case of fire. The main supply is derived from Ouachita River. In 1898 Mr. Strong gave the following record of this well:

33Report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific Rwy.; Geol. and Agric. of La., pt. 1, 1893, pp. 45-47.

Section of waterworks well No. 1, Monroe, Ouachita, Parish, La.

[By Will A. Strong.]

	Feet.
Port Hudson:	
1. Clay and quicksand	c– 80
Claiborne and Sabine:	
2. Soft bluish clay	80–180
3. Blue marl, with shells	180–190
4. Rock	190–191
5. Soft blue pipe clay	191–289
Sabine:	
6. Water-bearing sand	289–385

The water first began to flow at 289 feet and the flow increased with the depth.

924. *Analysis of water from deep well of Planters' Oil Company, Monroe, Ouachita, Parish, La.*[34]

[By Maurice Bird.]

	Parts per million
Soluble silica	71.820
Iron and alumina	52.668
Lime	7.182
Magnesia	14.364
Potash	7.524
Soda	252.909
Chlorine	53.865
Sulphuric acid	9.234
Phosphoric acid	None.
Nitrogen as nirates	None.
Nitrogen as nitrites	None.
Nitrogen as ammonia	None.
Carbonic acid	102.942

928. *Sections of test borings in Ouachita River at Monroe, Ouachita Parish, La. (183.4 miles above mouth of Black River).*[35]

BORING No. 20.

	Depth in feet.
1. Brown sand	0 00
2. Gray sand	17.39
3. Blue-black clay and sand	40.22
4. Blue-black clay and sand	51.38

[34] Report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific R'y. Geol. and Agric. of La., pt. 1 1893; pp. 45–47.

[35] Ann. Rept. Chief of Engineers for 1902 pp. 1564–1565.

BORING No. 20a.

		Depth in feet.
1.	Brown sand and clay	0.00
2.	Brown sand	3.28
3.	Grayish sand	22.96
4.	Blue-black clay, with some mud	36.28
5.	Blue-black clay, with some mud	50.20

BORING No. 20b.

1.	Yellow sand and mud	0.0
2.	Gray sand	6.56
3.	Coarse sand mixed with gravel and mud	22.31
4.	Coarse bits of broken gravel and sand	23.95
5.	Sand	25.59
6.	Fine sand and mud	27.23
7.	Mud	28.55
8.	Blue mud	31.50
9.	Mud and sand	33.79
10.	Mud	36.42
11.	Mud and sand	41.01
12.	Mud and sand	43.97

BORING No. 20c.

1.	Clean white sand	0.00
2.	Yellow sand	5.26
3.	Wet brown sand	5.58
4.	Wet black sand	5.91
5.	Gray sand	12.47
6.	Fine sand and mud	35.86
7.	Blue clay	39.77

929. *Sections of test borings in Ouachita River at Rock Row Shoals Ouachita Parish, La. (200.9 miles above mouth of Black River).*[36]

BORING No. 21.

		Depth in feet.
1.	Brown-gray sand, with small percentage of clay	0.00
2.	Brown sand	1.64

[36] Ann. Rept. Chief Engineers for 1902, pt. 2, pp. 1565-1566.

Claiborne:	Depth in feet.
3. Very stiff clay and greensand marl	24.27
4. Very stiff clay and greensand marl, with a few shells	49.70
5. Rock	62.73
6. Very stiff clay and greensand marl, with a few shells	62.99
7. Same clay, with more greensand and pieces of rounded rock, size 1 inch	69.62
8. Rock	70.99
9. Greensand, with small precentage of clay	71.68
10. Greensand and clay	74.45
11. Stiff clay, with some greensand and a few small shells	78.74
12. Very stiff blue-black clay, with a few small shells	82.02
13. Rock	102.39
14. Very stiff blue-black clay, with a few small shells	102.72
15. Very stiff dark-brown clay and sand, with some shells	117.97
16. Gray rock, very hard and full of shells	126.31
17. Dark-gray sand and clay, with shells	126.46
18. Rock	131.36
19. Blue-black clay, with shells and sand	131.69
20. Gray and green rock full of shells	146.78
21. Very stiff clay, with shells and pockets of sand	149.14
22. Gray-green rock full of shells	153.70
23. Very stiff clay, with shells and sand	155.02
24. Gray-green rock full of shells	156.39
25. Gray-green rock full of shells	157.05

BORING No. 21a.

	Depth in feet.
1. Brown-gray sand and mud	0.00
2. Greensand marl, with large precentage of clay	16.40
3. Stratum of rock about 1 inch thick	40.35
4. Very stiff greensand and clay	48.49
5. Very stiff mud or soft rock	62.79

983–986. In 1894 and 1895 four wells were put down by the city of Alexandria—two near the corner of Monroe and Fourth streets, where the waterworks now stand; one behind the city hall, and the fourth on the corner of St. James and Fourth streets. All these were flowing wells, the water rising from 4 to 10 feet above the surface, and were used at first to supply public watering troughs. After the installation of the waterworks in 1895, the yield of the wells at the city hall and St. James and Fourth streets gradually decreased. For several years they would cease flowing when pumping began at the waterworks, and recommence about three hours after the pumps, had stopped. Since 1899 they have not flowed at all and the water level is gradually lowering. On August 6, 1902, it was found to be from 58 to 60 feet below the surface in the city-hall well, and 49 feet in the well at St. James and Fourth streets.

No record was kept of these wells, and the various reports received concerning them are very contradictory and confusing. The following represents the best data obtainable:

Well behind city hall.—Diameter, 1.5 inches; completed in 1894; flowed intermittently until 1899, the water supplying a public watering trough. On August 6, 1902 the well was sounded and found to be 473 feet deep; about 20 feet of sand had accumulated in the bottom, but the plumb bob finally reached hard clay.

Waterworks well No. 1.—Diameter, 4 inches; strainer, 2.5 inches; completed 1898. Mr. H. C. Kenneker, foreman in charge of the drilling, states that the well is 560 feet deep, the water-bearing sand extending from 540 to 560 feet. This, with well No. 2, was pumped with a direct-suction pump from 1895 to 1901, when an air lift was installed. The air-lift pipe is 198 feet long, and the air pressure on August 4, 1902, indicated that the water was at that time approximately 138 feet from the surface. Mr. Ira W. Sylvester, city engineer, states that it takes over a day for the water in No. 1 to rise to within 3 feet of the surface. Yield of well April 16, 1902, 53 gallons in 27 seconds.

Waterworks well No. 2.—Diameter, 10 inches, 0–210 feet; 8 inches, 210–612 feet; 4 inches, 612–760 feet. Mr. H. C. Kenneker, the driller, reports that water-bearing sand was encountered at 540, 620 and 760 feet, and that strainers were placed at each of the sands. Mr. Ira W. Sylvester, city engineer, is of the opinion that there are no strainers in the well at 540 and 620 feet, because pumping well No. 2 does not affect the water level in well No. 1. Yield of well April 16, 1902, 53 gallons in 26 seconds. On August 6 the depth of water was about 110 feet.

Well corner St. James and Fourth streets.—Diameter, 2 inches; flowed originally 10 feet above the surface; flowed intermittently from 1894 until 1899. On August 6, 1902, well was sounded and found to be 606 feet deep;

bottom of the casing was filled with about 50 feet of sand; plumb bob finally struck hard bottom.

In order to obtain some idea of the effect of pumping the waterworks wells a number of observations were made on the wells at the city hall and St. James and Fourth streets, on August 6 and 7, 1902. Both of the waterworks wells had been pumped steadily up to this time, and well No. 1 was cut out from 10.15 a. m. to 6 p. m., August 6. The water in the city hall well rose steadily after the pumping of No. 1 ceased, indicating that these two wells depend on a common horizon. The well at the corner of St. James and Fourth streets, however, did not show any fluctuation which could clearly be attributed to the increased demand on well No. 2.

987. In 1900 a well was started for the St. Louis, Iron Mountain and Southern Railway, near the round-house, by the Hart Well Company. Mr. Hart has furnished the following statement regarding it: "The well was drilled to a depth of 858 feet. Water was struck at 850 feet, but, through a disagreement with the railroad company, was not developed. A considerable thickness of sandstone was penetrated before reaching 850 feet; below, this was loose sand."

The following has been taken from a blueprint, dated February, 1890, on file in the Iron Mountain Railway office at Bearing Cross, Ark.:

Partial record of well of St. Louis, Iron Mountain and Southern Railway, Alexandria, Rapides Parish, La.

	Feet.
Port Hudson:	
1. Soil	0– 60
2. White sand	60– 75
3. Yellow sand	75– 80
4. Bowlders	80– 90
Catahoula:	
5. Solid rock	90–110
6. "Slate" (blue clay), and sand rock	110–390
7. Sand rock	390–402
8. "Shale" (blue clay), sand rock, and blue soapstone (blue clay)	402–520
9. Sand rock	520–528
10. "Shale" (blue clay), sand rock, and blue soapstone	528–530

Casing, 6-inch, 0-300 feet; 4-inch, 300-482 feet.

988. In 1902 two test wells were put down on the property of the Alexandria Ice and Storage Company, near the corner of Monroe and Sixth streets, by the Andrews Well Company. Mr. James Drouant, foreman, has furnished the following data: "In well No. 1 water was struck at 480 and 580 feet; stratum at 480 feet yield 60 gallons per minute; water from 580 feet stood within 60 feet of the surface."

Section of second test well of the Alexandria Ice and Storage Company, Alexandria, Rapides Parish, La.

[By James Drouant.]

	Feet.
1. Clay	0–150
2. White sand	150–155
3. Clay	155–176
4. Rock	176–180
5. Clay	180–330
6. Sandstone	330–375
7. Clay	375–410
8. Shale	410–450
9. Sand	450–510
10. White rock	510–520
11. Clay	520–545
12. Sand	545–580
13. Green clay, typical Catahoula (Grand Gulf) material	580–621

These horizons are clearly the same as those developed in the waterworks wells. The depth to the water is about what would be expected because of the depression of the water table produced by the pumping at the waterworks.

As neither of these wells furnished the amount of water required by the ice factory, they were abandoned.

989. After the abandonment of the two Andrews test wells, a new well was drilled by the Hart Well Company on the Fifth street line of the property. Harris gives the following section:

Section of well of Alexandria Ice and Storage Company, Alexandria, Rapides Parish, La.[37]

[By G. D. Harris.]

	Feet.
1. Surface clay	0 – 21
2. Sand	21 – 23
3. Clay	23 – 38

[37] Water-Sup. and Irr. Paper No. 101, U. S. Geol. Survey, 1904, p. 20.

4.	Rock	38 - 65
5.	Blue clay	65 -153
6.	Hard rock	153 -155
7.	Blue clay	155 -175
8.	Rock	175 -183
9.	Blue joint clay	183 -328
10.	Limestone	328 -331
11.	Clay	331 -374
12.	Hardpan	374 -464
13.	Hard limestone	464 -466.5
14.	Green clay	466.5-478.5
15.	Hard rock	478.5-480
16.	Blue clay	480 -490
17.	Sandstone	490 -504
18.	Clay	504 -534
19.	Sand	534 -537
20.	Rock	537 -539
21.	Clay	539 -549
22.	Sand	549 -550
23.	Clay	550 -558
24.	Sand	558 -560
25.	Blue clay	560 -649
26.	Sand	649 -665
27.	Clay	665 -693
28.	Sand	693 -703
29.	Blue clay	703 -727
30.	Soft sandstone	727 -780
31.	Clay	780 -804
32.	Sand	804 -809
33.	Soft sandstone	809 -851
34.	Clay	851 -853
35	Sandstone	853 -897
36.	Sand	897 -927

"This well is provided with a 70-foot strainer, and before it was cleaned had a flow of 125 gallons a minute, according to the report of a local paper."

The fact that this is a flowing well indicates a stratum entirely distinct from those developed in the waterworks wells.

940. *Section of well of Sonia Cotton Oil Company, Alexandria, Rapides Parish, La.*

[By Ira W. Sylvester.]

	Feet.
Port Hudson:	
1. Sandy soil	0- 5
2. Clay	5- 60
3. Shelly rock	60- 65
4. Sharp sand, water bearing	65- 95
5. Clay and gravel	95-110
Sabine:	
4. Rock	64-
5. Clay	- 77
6. Lignite	77- 85
7. Fine sand, with turbid water	85-
8. Rock	115-116
9. Fine sand, water bearing	116-
10. No record	-287.5

Casing, 4-inch, 0-85 feet; 2.5-inch, 85-168 feet. Water was brackish and well is not used.

941. *Section of well of Ball Sawmill Company, Ball, Rapides Parish, La.*

[By Oscar Shanks.]

Catahoula:	
1. Yellow clay	0- 17
2. Soft blue sandstone	17- 22
3. Fine sand and clay	22- 48
4. Medium sandstone	48- 60
5. Blue clay	60-310
6. Fine water sand mixed with lignite and mica	310-365

This stratum was cased off and an attempt made to get flowing water, but the well was abandoned.

948. *Section of well of Texas and Pacific Railroad Company, Boyce, Rapides Parish, La.*

[By Charles Anderson]

	Feet.
1. Clay	0 - 42
2. White sand	42 - 62
3. Hard clay	62 - 82

		Feet.
4.	Clay and sand	82 -145
5.	Sandstone	145 -156
6.	Clay	156 -180.5
7.	Sandstone	180.5-204.2
8.	Sand	204.2-215.2
9.	Blue clay	215.2-217.2
10.	Flint Rock	217.2-221.2
11.	Hard clay	221.2-263.2
12.	Quicksand	263.2-279.2
13.	Clay	279.2-281.2
14.	Sand and clay	281.2-300.2
15.	Clay	300.2-318.4
16.	Sandstone	318.4-325.4
17.	Clay	325.4-329.4
18.	Sandstone,	329.4-335.4
19.	Clay	335.4-344.4
20.	Sandstone	344.4-368.4
21.	Clay	368.4-376.4
22.	Sandstone	376.4-398.4
23.	Clay	398.4-411.4
24.	Flint rock (quartzite)	411.4-418.8
25.	Clay	418 8-438.8
26.	Sandstone	438.8-441.2
27.	Clay	441.2-529.2
28.	Sandstone	529 2-531.2
29.	Hardpan	531.2-541.2
30.	Gravel and clay	541.2-616
31.	Sandstone	616 -696
32.	Sand, with artesian water	696 -708
33.	Flint rock (quartzite)	708 -711
34.	No record	711 -774
35.	Soft sandstone	774 -802
36.	Soft sandstone, with brackish artesian water.	802 -808.6

"Depth September 14, 1898, 808.6 feet. Pipe was pulled back to 696 feet and well used until 1901, when it caved."

944. When this well is pumped the water lowers to 40 feet from the surface. It requires about eight days to entirely recover—that is, to flow. The original pressure at the top of the pipe was 15 pounds to the square inch.

947. *Section of well of L. C. Sanford, Lamothe, Rapides Parish, La.*

[By L. C. Sanford.]

Port Hudson:	Feet.
1. Soil, sand and clay	0– 35
2. Quicksand; does not yield the water readily	35– 80
3. Tough red clay	80– 95
4. Sand and gravel, with abundant supply of hard water	95–105

950. *Sections of wells of Pineville Development Company, Pineville, Rapides Parish, La.*

[By F. S. Hoyt.]

WELL No. 1.	Feet.
1. Gravel, water bearing	200 –
2. Light-greenish clay (Catahoula)	235.5–
3. Gravel, water bearing; water flowed out of pipe 55 feet above the ground for four hours	430 –440
4. Sand; lost water at	460 –
5. Soft limestone	580 –600
Total depth	–720

WELL No. 2.

1. Clay, with a little sand	0 –100

WELL No. 3.

1. Soil	0 – 12
2. Packed sand	12 –112
3. Rock	112 –124
4. Gravel from size of pea to that of a hen's egg, with a little water	124 –230
Total depth (August 8, 1902)	–230

951. Mr. Oscar Shanks has furnished the following samples from this well:

Samples from asylum well, Pineville, Rapides Parish, La.

	Feet.
1. Medium to coarse reddish-yellow quartz sand	20– 24
2. Fine white indurated sand	24– 35
3. Very fine light-gray sandy silt	52– 92

	Feet.
4. Clay conglomerate, composed of small rounded clay pebbles containing considerable lime....	228- 324
5. Fine-grained white sand.....................	324- 328
6. Light-gray clay with rounded calcareous clay pebbles..................................	328- 428
7. Hard gray fine-grained quartzitic sandstone....	455- 461
8. Green clay..................................	461- 540
9. Green clay and fine gray sand	540- 610
10. Green clay and fine gray sand, with numerous thin calcareous plates that resemble shell fragments, but which cannot be definitely proved to be of organic origin	610- 650
11. Greenish-gray clayey sand.....................	720- 800
12. Medium white sand, with a little clay	800- 806
13. Very fine gray clayey sand.....................	806- 925
14. Rounded white calcareous concretions, lignite and gray laminated lignitic sand	927-
15. Greenish clay, lignite and sand; a few thin white calcareous plates similar to those in sample 10..................................	925- 985
16. Fine greenish-gray sand	985-1,020

952. *Section of well at Judge Morrow's residence, near Rapides, Rapides Parish, La.*

[By C. A. Morrow.]

	Feet.
Port Hudson:	
1. Soil	0- 8
2. Red clay....................................	8- 77
3. Sand	77-102
4. Gravel	102-106

953. *Partial section of deep test well near Rapides, Rapides Parish, La.*

[By C. A. Morrow.]

	Feet.
Port Hudson:	
1. Soil	0- 8
2. Red clay	8- 77
3. Sand...	77-102
4. Gravel	102-108
Catahoula:	
5. Clay...	108-180
6. White sand, water bearing; water soft and pure and did not overflow........................	180-

7. Artesian water	288-
8. Quicksand, which forced its way up in the pipe 80 feet and caused the well to be abandoned	323-

956. *Section of well of J. A. Bentley Lumber Company, Zimmerman, Rapides Parish, La.*

[By J. A. Bentley.]

	Feet.
Port Hudson:	
1. Alluvial deposits	0 - 60
Catahoula:	
2. Soft rock and clay, alternating	60 -175.5
3. Rather coarse white sand, containing artesian water	175.5-

960. *Partial section of well at Lake End, Red River Parish, La.*

[By Charles Stoer.]

	Feet.
Port Hudson:	
1. Clay soil	0-
2. Quicksand.	
3. Gravel	- 64

966. Mr. W. A. Shields, superintendent, reports water bearing sand at the following depths: 188–190, 220–230, 251–264, 436–444, 460–462, 505–507, 524–528, 536–540, 545–549, 560–566, 670–704 feet. Screens have been placed opposite each of these layers. At 454 and 557 feet a little oil is reported. Mr. L. B. Clifford, the driller, states that seven beds of lignite were encountered in this well.

Mr. Robert Moechel reports the following: "Reaction, faintly alkaline to litmus. Appearance, turbid, with brown sediment. Microscopically, the sediment showed the presence of refuse matter. The water after twenty-four hours' sedimentation contained the following:

Analysis of water from deep well at Loring, Sabine Parish, La.

[By Robert Moechel.]

	Parts per million.
K_2O	15.91
Na_2O	25.66
Cl	27.0C
SO_3	15.45
NO_3	1.77
SiO_2	50.20
Al_2O_3 (in clay)	1.20

$Fe_2O_3+Al_2O_3$	7.10
CaO	2.68
MgO	1.44
SO	1.47

HYPOTHETICAL COMBINATION.

Sodium chloride	43.67
Potassium sulphate	27.79
Sodium sulphate	91.94
Sodium nitrate	2.43
Sodium carbonate	4.30
Silica+clay	51.40
Iron+alumina	7.10
Calcium sulphate	2.49
Calcium carbonate	2.94
Magnesium carbonate	3.02

"Suspended and settled matter contains 531.2 parts of solid matter per million, composed of 42.9 parts mineral matter, quite a per cent of which is phosphates.

"This is not a mineral nor sanitary water analysis. Determinations have been made so as to be able to render an intelligent opinion as to the suitability of this water for economically generating steam, etc. This water contains sewage."

From a knowledge of the location and surroundings of this well, the writer is inclined to believe that the water is not contaminated. Water derived from these lignitiferous beds containing considerable organic matter and chlorine must necessarily show characteristics which are in other regions interpreted as indicating sewage. This well is situated on a knoll with no polluting source near it; is cased and the water sands amply protected by clayey layers. So far as the possibilities of pollution are concerned the deep-well water is greatly to be preferred to the water from the shallow wells which are now exclusively used at this place for the supply of drinking water.

969. *Section of Foster well, 2.5 miles southwest of Negreet, Sabine Parish, La.*[38]

[By William Kennedy.]

	Feet.
1. Soil and clay	0– 18
2. Quicksand	18– 23
3. Blue clay, changing to blue shale	23– 50
4. Blue limestone	50– 52

[38]Bull. U. S. Geol. Survey No. 212, 1903, p. 55

5. Blue clay, with bowlders; first sign of oil at 75 feet	52– 75
6. Blue shale, oil signs, and plenty of gas	75–200
7. Lignite	200–205
8. Blue shale and gas	205–340
9. Brown gummy shale, oil on water	340–350
10. Blue shale, with oil and gas	350–430
11. Slate colored talcky rock	430–494
12. Bluish-gray lime rock, very hard; gas blew out drillings	494–502
13. Tan-colored shale, with yellow sand	502–542
14. Milky-white talcose rock	542–580
15. Blue shale, with small white pebbles	580–600
16. Blue, hard, and flinty limestone; gas under this rock	600–604
17. Shells and pebbles, with strong indications of oil and much gas	604–630

971. The water-bearing layer at 160 feet is very thin, and was developed by pumping sand out until a sufficient cavity was made to yield a fair supply of water. There is no strainer in the well.

972. *Analysis of water from Ferrell's mineral well, near Pleasant Hill, Sabine Parish, La.*

[By Maurice Bird.]

	Parts per million.
Silica	61.56
Peroxide of iron and alumina	10.26
Calcium	875.52
Magnesia	1,134.02
Potash	3.42
Sodium	884.07
Sulphuric anhydride	3,062.61
Chlorine	2,110.14
Carbonic acid	206.91
Oxygen absorbed from potassium permanganate in three hours	1.642

HYPOTHETICAL COMBINATION.

Sodium chloride (common salt)	2,241.1
Calcium chloride	1,162.8
Calcium sulphate	1,368.0
Magnesium sulphate	3,231.9
Magnesium bicarbonate	171.0

"On ignition, the residue obtained from evaporation fuses and darkens, quickly becoming white, however. The water is perfectly clear and colorless and does not contain sufficient organic matter to make it unwholesome. The mineral ingredients of this water are so high that it may properly be called a medicine, and for this reason it should be used only in cases of sickness, and then only upon the prescription of a physician who is acquainted with its composition. The reaction of the water with litmus is slightly acid."

974. Mr. Coxe, superintendent, reports that a small vein of lignite was encountered at about 75 feet; and that three water-bearing sands were encountered between 100 and 195 feet, the one between 100 and 120 being the thickest of the three.

975. *Section of well of Latannier Oil Company, 12 miles south of Melville, St. Landry Parish, La.*

[By Oscar Shanks.]

	Feet.
1. River deposits	0– 20
2. Blue clay	20– 150
3. Gravel and bowlders	150– 232
4. Hard blue flinty rock	232– 336
5. Caving brown gravel	336– 532
6. Hard blue flinty rock	532– 537
7. Coarse blue sand, with a large flow of pure soft water	537– 555
8. Gumbo shale	555–1,452
9. Pepper-and-salt sand, with a strong flow of water having a slight sulphur taste	1,452–1,458
10. Strata of gumbo and rock containing strong artesian sulphur water	1,458–2,003

Occasional layers of sand and shells are reported in stratum 10.

978. *Sections of test borings in Ouachita River at Loch Lomond, Union Parish, La.*[39]

BORING No. 22.

	Depth in Feet.
1. Brown sand, with small percentage of gravel	0.00
2. Greensand marl, with medium percentage of clay	20.47
3. Greensand marl, with small percentage of clay	34.48
4. Very stiff greensand and mud	42.16
5. Very stiff greensand and mud	50.00

[39]Ann. Rept. Chief of Engineers for 1902, pt. 2, 1902, p. 1566.

BORING No. 22a.

	Depth in Feet.
1. Brown sand and mud	0.00
2. Brown sand, with small percentage of gravel	0.99
3. Greensand marl, with large percentage of clay	13.88
4. Greensand marl, with small percentage of clay	32.68
5. Very stiff greensand and mud	39.37
6. Very stiff greensand and mud	50.00

982. *Analyses of brines from Bisteneau Salt Works, Webster Parish, La.*[40]

[By Maurice Bird.]

Constituents (in parts per hundred).	Bryan's well.	Potters Pond	Head of Salt Island.
Sodium chloride	8.450	7.810	3.800
Calcium chloride	.234	.301	.081
Magnesium chloride	.102	.156	.083
Alumina	.056	.052	.056
Other solid matter	.088	.061	.058

983. *Section of well of Valley Lumber Company, Cotton Valley, Webster Parish, La.*

[By L. B. Cifford.]

	Feet.
1. Red clay	0– 40
2. Red sand	40– 45
3. Blue clay and rock	200–245
4. White sand	245–271

985. *Section of well of Minden Lumber Company, Minden, Webster Parish, La.*

[By C. L. Whitmarsh.]

Sabine:	Feet.
1. White clay	c– 20
2. Fine sand	20– 70
3. Clay	70– 71
4. Lignite (1 foot thick)	71– 72
5. Sand and clay	72–110
6. Coarse whitc water-bearing sand	110–120

[40] Geol. Survey Louisiana, Rept. of 1902, p. 89.

	Feet
7. Clay	120–244
8. Lignite	244–247
9. Water-bearing sand, increasing in coarseness with depth	247–317

986. Mr. L. B. Clifford states that the sand encountered in this well at 110 feet, which furnishes water at the ice factory, yields practically no water at this point.

988. *Section of well of Minden Cotton Oil and Ice Company, Minden, Webster Parish, La.*

[By S. G. Webb, president.]

	Feet.
Sabine?:	
1. Surface sands and clay	0– 60
2. Sand	60– 75
Sabine:	
3. Dark-colored clay	75–100
4. Water sand	100–115

989. The water from the lower layer in this well is shut out and the well draws entirely from the stratum between 228 and 270 feet. Both horizons furnish good soft water.

990. Mr. A. L. Pullin states that he worked on this well until it reached a depth of 750 feet and that the well was afterwards drilled to a depth of 1,015 feet. He gives the following partial record:

Partial record of well at Yellow Pine, Webster Parish, La.

[By A. L. Pullin.]

	Feet.
1. Log at	280–
2. Layers of rock.	
3. Marl that looks like slack lime	600–640
4. Rock	640–680
5. Blue clay, with a very offensive smell	680–750

"No water was encountered to a depth of 750 feet. Casing, 4-inch, 0–500; 3-inch, 500–750."

Mr. H. C. Walter, woods foreman for the Globe Lumber Company, who was at Yellow Pine when the well was drilled, gives the total depth as 800 feet. He says: "The matter passed through was a black sticky clay, with a very bad odor, and was full of shells of all kinds. In some places the

clay changed to very hard rock. At a depth of 500 feet a log was struck which was supposed to be a cypress. They finally struck a very hard substance, which effectully stopped work with a rotary rig."

991. *Section of well of Texas and Pacific Railway, Baton Rouge Junction, West Baton Rouge Parish, La.*

[By Charles Anderson.]

	Feet.
1. Black clay	0– 10
2. Heavy clay	10–100
3. Quicksand	100–110
4. Coarse sand, not passed through	110–

994. *Analyses of brines from Drakes Salt Works, Winn Parish, La.*[41]

[By Maurice Bird.]

Constituents (in parts per hundred).	I.	II.	III.	IV.
Sodium chloride	4.90	3.55	5.58	5.44
Calcium chloride	.184	.127	.303	.356
Magnesium chloride	.142	.133	.135	.159
Alumina	.061	.066	.072	.055
Other solid matter	.083	.044	.070	.030

I. Little lick, west side, old Drake well.
II. Smith's lick.
III. Lower lick, old Drake well.
IV. Upper lick, south side, in slough.

995. *Analysis of brine from Price's Salt Works, Winn Parish, La.*[42]

[By Maurice Bird.]

	Per cent.
Sodium chloride	3.14
Calcium chloride	.079
Magnesium chloride	.138
Alumina	.050
Other solid matter	.030

999. This well was largely through porous crystalline limestone similar to that seen in a number of Cretaceous exposures in northern Louisiana. Between 250 and 260 feet a large amount of gas was encountered, which was used for fuel in the engines of the drilling machines. The well was finally abandoned because of the heavy gas pressure, and the company planned to start a new hole in January, 1904. Two small oil-bearing layers are reported.

41 Geol. Survey Louisiana, Rept. of 1902, pp. 63–64.
42 Geol. Survey Louisiana, Rept. of 1902, p. 69

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